



U.S. ENVIRONMENTAL PROTECTION AGENCY

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TECHNICAL  
ASSISTANCE  
TEAM

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FINAL  
REMOVAL ACTION/  
FEASIBILITY STUDY REPORT  
FOR THE  
NATIONAL LEAD INDUSTRY SITE  
PEDRICKTOWN, NEW JERSEY



*Region II*

**ROY F. WESTON, INC.**

Spill Prevention & Emergency Response Division  
In Association with ICF Technology Inc., C.C. Johnson & Malhotra, P.C.,  
Resource Applications, Inc., Geo/Resource Consultants, Inc., and  
Environmental Toxicology International, Inc.



**WESTON**  
MANAGERS DESIGNERS/CONSULTANTS

**FINAL  
REMOVAL ACTION/  
FEASIBILITY STUDY REPORT  
FOR THE  
NATIONAL LEAD INDUSTRY SITE  
PEDRICKTOWN, NEW JERSEY**

**JUNE 8, 1990**

**EPA CONTRACT NO. 68-01-7367**

**TECHNICAL ASSISTANCE TEAM  
ROY F. WESTON, INC.  
MAJOR PROGRAMS DIVISION  
EDISON, NEW JERSEY 08837**

## TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
EXECUTIVE SUMMARY	3
1.0 INTRODUCTION	3
1.1 Site History	6
1.2 Objectives of Feasibility Study	6
2.0 WASTE CHARACTERIZATION	6
2.1 Slag Piles	6
2.2 Lead Oxide Piles	7
2.3 Other Waste Areas	7
2.4 Wipe Samples From Process Building	10
2.5 Standing Water	10
3.0 PUBLIC HEALTH EVALUATION	10
3.1 Identification of Exposure Pathways	11
3.1.1 Air	11
3.1.2 Surface Water	12
3.2 Development of Cleaning Goals	12
4.0 TECHNOLOGY SCREENING	16
4.1 No Removal Action - Upgrading Security	16
4.1.1 Description	16
4.1.2 Areas of Site	16
4.1.3 Technology Considerations	19
4.1.4 Other Considerations	19
4.1.5 Recommendation	19
4.2 Minimal Mitigative Action	19
4.2.1 Description	19
4.2.2 Areas of Site	19
4.2.3 Technology Considerations	20
4.2.4 Other Considerations	20
4.2.5 Recommendation	20
4.3 Hazardous Waste Handling	20
4.3.1 Description	20
4.3.2 Areas of Site	20
4.3.3 Technology Considerations	20
4.3.4 Other Considerations	21
4.3.5 Recommendation	21

TABLE OF CONTENTS  
(Continued)

<u>Section</u>	<u>Page</u>
4.4 Incineration/Roasting	21
4.4.1 Description	21
4.4.2 Areas of Site	21
4.4.3 Technology Considerations	23
4.4.4 Other Considerations	23
4.4.5 Recommendation	23
4.5 Extraction/Waste material Washing	23
4.5.1 Description	23
4.5.2 Areas of Site	25
4.5.3 Technical Considerations	25
4.5.4 Other Considerations	25
4.5.5 Recommendation	25
4.6 In-Situ Waste Material Flushing	26
4.6.1 Description	26
4.6.2 Areas of Site	26
4.6.3 Technical Considerations	26
4.6.4 Other Considerations	26
4.6.5 Recommendation	27
4.7 In-Situ Vitrification	27
4.7.1 Description	27
4.7.2 Areas of Site	27
4.7.3 Technical Considerations	27
4.7.4 Other Considerations	29
4.7.5 Recommendation	29
4.8 Stabilization/Solidification	29
4.8.1 Description	29
4.8.2 Areas of Site	29
4.8.3 Technical Considerations	29
4.8.4 Other Considerations	31
4.8.5 Recommendation	31
4.9 Hydro-Metallurgical Leaching Process	31
4.9.1 Description	31
4.9.2 Areas of Site	31
4.9.3 Technical Considerations	33
4.9.4 Other Considerations	33
4.9.5 Recommendation	33

## TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
4.10 Hydroblasting Method	34
4.10.1 Description	34
4.10.2 Areas of Site	34
4.10.3 Technical Considerations	34
4.10.4 Other Considerations	34
4.10.5 Recommendation	34
4.11 Bleaching Process	34
4.11.1 Description	34
4.11.2 Areas of Site	36
4.11.3 Technical Considerations	36
4.11.4 Other Considerations	36
4.11.5 Recommendation	36
4.12 Solvent Washing Technology	37
4.12.1 Description	37
4.12.2 Areas of Site	37
4.12.3 Technical Considerations	37
4.12.4 Other Considerations	37
4.12.5 Recommendation	37
4.13 Ion Exchange	39
4.13.1 Description	39
4.13.2 Areas of Site	40
4.13.3 Technical Considerations	40
4.13.4 Other Considerations	40
4.13.5 Recommendation	42
4.14 Chemical Precipitation/Separation	42
4.14.1 Description	42
4.14.2 Areas of Site	42
4.14.3 Technical Considerations	42
4.14.4 Other Considerations	42
4.14.5 Recommendation	44
4.15 Summary	44

## TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
5.0 EVALUATION OF REMEDIAL ACTION ALTERNATIVES	45
5.1 Background	45
5.1.1 Development of Alternatives	45
5.1.2 Site Specific Considerations and Remedial Approach	45
5.1.3 General Waste Considerations	46
5.1.4 Cost Evaluation	47
5.2 Alternative 1 - No Remedial Action	47
5.2.1 Non Cost Criteria	48
5.2.1.1 Technical Considerations	48
5.2.1.2 Institutional Considerations	48
5.2.2 Cost Criteria	48
5.3 Alternative 2 - Minimal Mitigative Action	48
5.3.1 Description	48
5.3.2 Non Cost Criteria	51
5.3.2.1 Technical Considerations	51
5.3.2.2 Institutional Considerations	51
5.3.2.3 Public Health and Environmental Issues	52
5.3.3 Cost Criteria	52
5.4 Alternative 3 - Hazardous Waste Handling/ Waste Material Washing	52
5.4.1 Description	52
5.4.2 Non Cost Criteria	57
5.4.2.1 Technical Considerations	57
5.4.2.2 Institutional Considerations	58
5.4.2.3 Public Health and Environmental Issues	58
5.4.3 Cost Criteria	58
5.5 Alternative 4 - In-Situ Vitrification Treatment	58
5.5.1 Description	58
5.5.2 Non Cost Criteria	63

## TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
5.5.2.1 Technical Considerations	63
5.5.2.2 Institutional Considerations	65
5.5.2.3 Public Health and Environmental Issues	66
5.5.3 Cost Criteria	66
5.6 Alternative 5 - Hydro Metallurgical Leaching Process	66
5.6.1 Description	66
5.6.2 Non Cost Criteria	72
5.6.2.1 Technical Considerations	72
5.6.2.2 Institutional Considerations	72
5.6.2.3 Public Health and Environmental Issues	73
5.6.3 Cost Criteria	73
5.7 Alternative 6 - Bleaching/Hydroblasting Process	78
5.7.1 Description	78
5.7.2 Non Cost Criteria	78
5.7.2.1 Technical Considerations	78
5.7.2.2 Institutional Considerations	78
5.7.2.3 Public Health and Environmental Issues	80
5.7.3 Cost Criteria	80
5.8 Alternative 7 - Ion Exchange	80
5.8.1 Description	80
5.8.2 Non Cost Criteria	83
5.8.2.1 Technical Considerations	83
5.8.2.2 Institutional Considerations	83
5.8.2.3 Public Health and Environmental Issues	83
5.8.3 Cost Criteria	83
5.9 Alternative 8 - Chemical Precipitation	83
5.9.1 Description	83
5.9.2 Non Cost Criteria	85

## TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
5.9.2.1 Technical Considerations	85
5.9.2.2 Institutional Considerations	85
5.9.2.3 Public Health and Environmental Issues	85
5.9.3 Cost Criteria	85
6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES	87
6.1 Basis of Comparison	87
7.0 REFERENCES	94
Appendix: Summary of Laboratory Analysis Data	



## LIST OF TABLES

<u>Table</u>	<u>Page</u>
2-1 Summary of Chemical Constituents From Five Waste Streams	9
3-1 Maximum Concentration of Contaminants for Characteristics of EP Toxicity	13
3-2 ECRA Contaminant Cleanup Levels Requirements for Hazardous Waste Site	14
3-3 National Interim Primary and Secondary Drinking Water Standards	15
4-1 Identification of Feasible Technology Types and Process Options	17
5-1 Alternative 1 - Preliminary Estimate, Total Cost - No Removal Action	49
5-2 Alternative 2 - Preliminary Estimate, Capital Cost - Minimal Mitigative Action	53
5-3 Alternative 2 - Preliminary Estimate, Operation and Maintenance Costs - Minimal Mitigative Action	54
5-4 Alternative 3 - Preliminary Estimate, Capital Cost - Excavation/Waste Material Washing	59
5-5 Alternative 3 - Preliminary Estimate of Operation and Maintenance Costs - Excavation/Waste Material Washing	62
5-6 Alternative 4 - Preliminary Estimate, Capital Cost - In-Situ Vitrification	67
5-7 Alternative 4 - Preliminary Estimate of Operation and Maintenance Costs - In-Situ Vitrification	69
5-8 Alternative 5 - Preliminary Estimate, Capital Cost Hydro-metallurgical Leaching Process	74
5-9 Alternative 5 - Preliminary Estimate of Operations and Maintenance - Hydro-metallurgical Leaching Process	77
5-10 Alternative 6 - Preliminary Estimate, Total Cost - Bleaching/Hydroblasting Process for Building Decontamination	81

LIST OF TABLES  
(continued)

<u>Table</u>	<u>Page</u>
5-11 Alternative 7 - Preliminary Estimate, Total Cost - Ion Exchange	84
5-12 Alternative 8 - Preliminary Estimate, Total Cost - Chemical Precipitation and Separation	86
6-1 Evaluation Summary of Remedial Alternatives for Waste Materials to be Treated	88
6-2 Present Worth Comparison	93

## LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1-1 Project Area Map	4
1-2 Site Plan	5
2-1 Waste Stream Sampling Location Map	8
4-1 Incineration/Roasting	22
4-2 Extraction/Waste Material Washing	24
4-3 In-Situ Vitrification	28
4-4 Stabilization/Solidification	30
4-5 Hydro-Metallurgical Leaching Process	32
4-6 Hydroblasting Process	35
4-7 Solvent Circulation Process	38
4-8 Ion Exchange	41
4-9 Chemical Precipitation and Separation	43
5-1 In-Situ Vitrification Process	64
5-2 Hydro-metallurgical Leaching Process - Pilot Plant Flow Sheet	70
5-3 Bleaching/Hydroblasting Process	79

## EXECUTIVE SUMMARY

The N.L. Industries site is an abandoned secondary lead smelting facility in Pedricktown, Salem County, New Jersey. The Delaware River is approximately 1.5 miles to the west of the site, and the nearest home is within 1000 feet of the site.

In 1972, the facility began recycling lead from car batteries. The sulfuric acid was removed for treatment and the casings crushed and buried in an on-site landfill. From 1973 through 1980, the New Jersey Department of Environmental Protection (NJDEP) cited the facility for numerous violations of state air and water standards. In 1982, N.L. Industries signed an Administrative Consent Order (ACO) with NJDEP to conduct a remedial program at the site. In September 1983, the U.S. EPA added this site to the National Priorities List (NPL) designation. In February 1983, the facility was sold to National Smelting of New Jersey (NSNJ). An amended ACO was signed by N.L. Industries defining cleanup responsibilities.

In 1986, N.L. Industries signed a consent order with the EPA whereby the firm assumed responsibility for conducting a long term Remedial Investigation/Feasibility Study (RI/FS) of the site. This was approved by the EPA on June 17, 1987. The EPA in 1989 provided site security by repairing existing fencing, and installing 900 feet of new fence to enclose the site. Slag pile encapsulation and general site cleanup was also done at this time.

There are several areas of contamination; processing buildings and equipment, slag piles, lead oxide piles, and other waste materials, such as deteriorated drums, fiber packs, and standing water. Each of these areas potentially presents a hazard to the public health, welfare and the environment.

Based on sampling and analysis of the waste streams, it was recommended that the hazardous materials be removed from the site before completion of the Remedial Investigation/Feasibility Study (RI/FS). The Removal Action/Feasibility Study (RA/FS) will address the available methods to remediate the site. All contaminated debris will be separated and staged on-site before implementation of removal action alternatives.

Because of the high lead content (20%), the proposed decontamination method of the solid hazardous waste material is a hydro-metallurgical process, similar to that used in the metal ores industry (see Sections 4.9 and 5.6). The lead oxide piles are best addressed by recycling. The process buildings will be decontaminated by using a bleaching/hydroblasting method. (See Section 4.10, 4.11 and 5.7).

This process will remove the lead dust from within the buildings. (See sections 4.9, 4.10, and 5.6). The standing surface water and the building decontamination water will be treated by ion exchange. (See sections 4.13 and 5.8).

Each of the technologies has been proposed with the health of the public being at the forefront. Other factors taken into account are the technical, institutional, and cost considerations associated with the site. Alternatives to these technologies are outlined in Table 6-1.

Cost of the various proposed treatment alternatives is shown in Table 6-1 on Page 88.

## INTRODUCTION

This Feasibility Study Report presents the conceptual engineering analysis of possible remedial actions to address contamination at the NL Industries site in Pedricktown, New Jersey. This report has been prepared under U.S. EPA TAT Contract Number 68-01-7367, in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986. Roy F. Weston Technical Assistance Team (TAT) is the lead technical firm for this investigation.

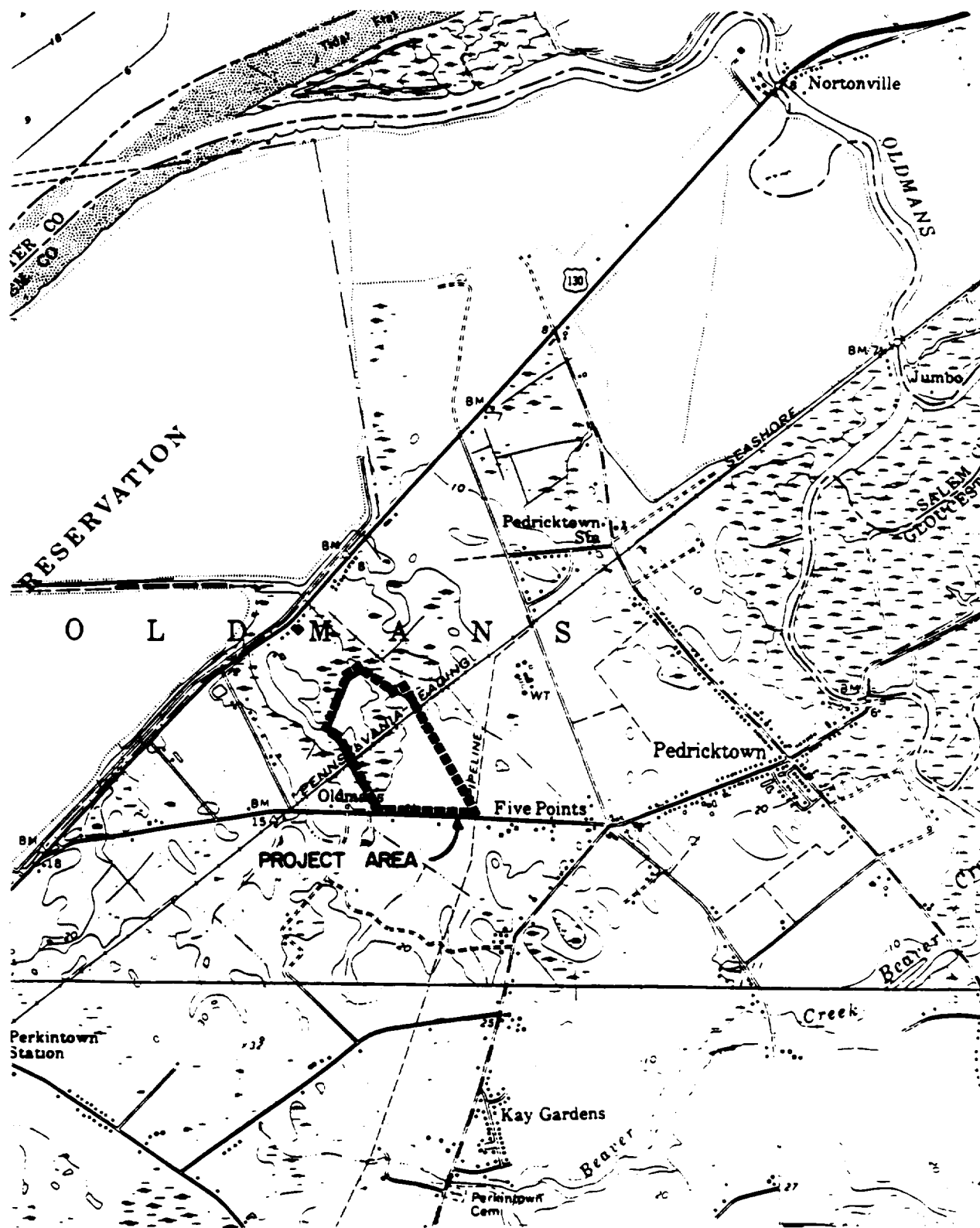
### 1.1 SITE HISTORY

The NL Industries site is an abandoned secondary lead smelting facility situated on 46 acres of land, approximately 1.5 miles from the Delaware River in Pedricktown, New Jersey (Figure 1.1). A residential area is located within 1000 feet of the site.

In 1972 the facility began the operation of recycling lead from spent automotive batteries. The batteries were drained of sulfuric acid, crushed, and then put through the lead recovery process at the on-site smelting facility (Figure 1-2). Plastic and rubber waste material were buried in an on-site landfill. The site came to the attention of the New Jersey Department of Environmental Protection (NJDEP) in 1973 and 1980 due to the violation of state air and water regulations. Water pollution violations were primarily directed at the battery and slag pile storage areas. NL Industries entered into an Administrative Consent Order (ACO) with NJDEP in 1982 to conduct a remedial program. That same year the site was placed on the National Priorities List (NPL).

In 1983 the NL property was sold to National Smelting of New Jersey, Inc. (NSNJ). NL and NSNJ signed an Amended ACO with NJDEP which defined cleanup responsibilities. NSNJ ceased operation in 1984 and declared bankruptcy. The bankruptcy case was dismissed in October, 1985. NL signed a consent order in 1986 with EPA whereby NL assumed responsibility for conducting a long term investigation at the site.

A public meeting was held on June 29, 1988 at which time EPA outlined the scope of RI/FS to be conducted at the site. Local residents expressed concern regarding the facility. Said concerns addressed: the need for a perimeter fence to limit public access; the threat of fire; and the contamination of shallow residential potable water wells. In December 1988 the EPA funding was approved and the EPA responded in April 1989 to local concerns by: repairing the existing fence; erecting an additional 900 feet of chain link fence; posting warning signs.



NOTE : Map adapted from U.S.G.S. Marcus Hook, Pa. - Penns Grove, N.J. Quadrangles



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EPA PM  
Eugene Dominach

FIGURE 1-1

In Association with ICF Technology Inc., C.C. Johnson & Associates, Inc., Resource Applications, Inc., Geo/Resource Consultants, Inc., and Environmental Toxicology International, Inc.

TAT PM  
V. Reddy/J. Menfreda

NL Industries  
Pedricktown, NJ

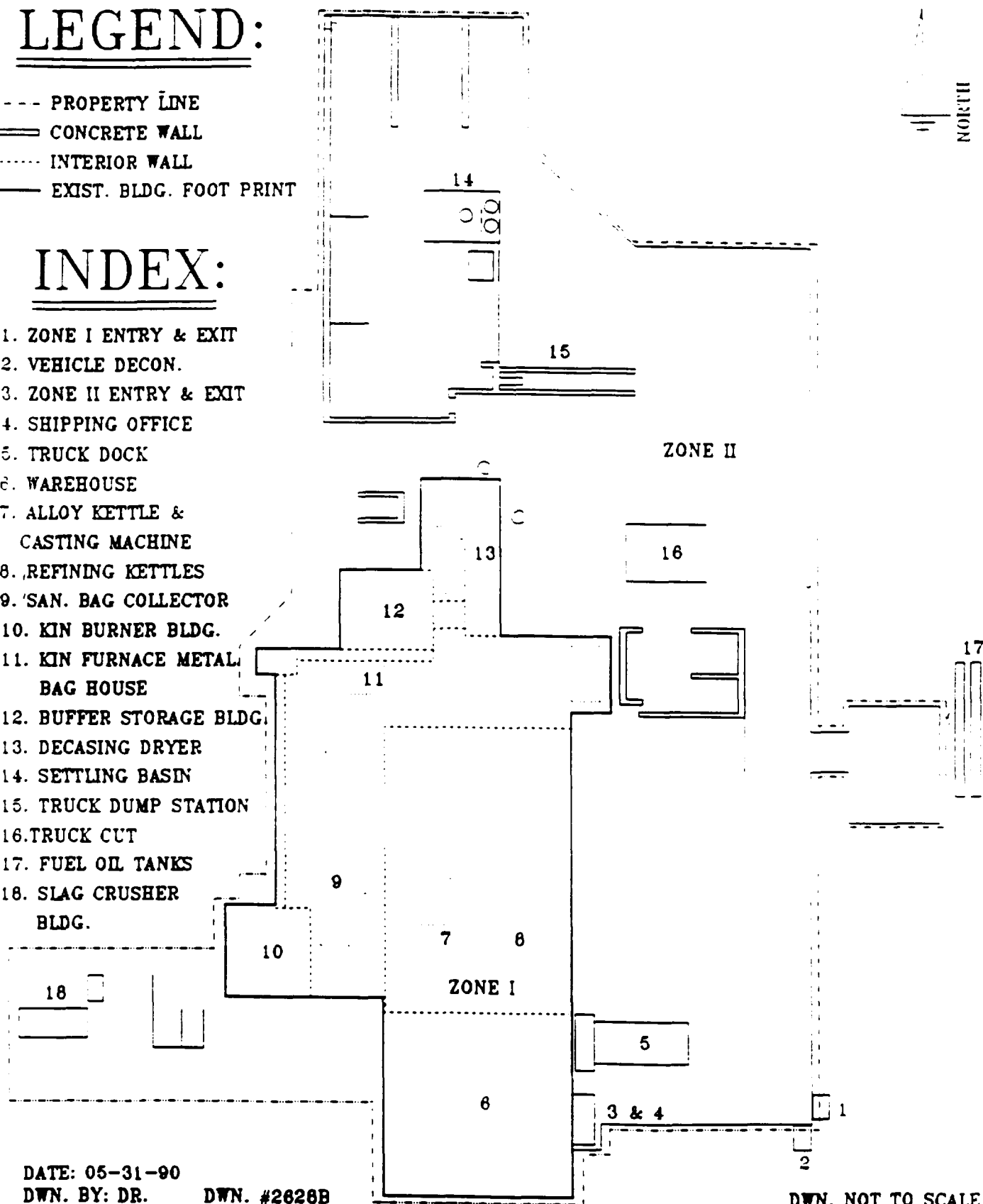
# SITE MAP

## LEGEND:

- PROPERTY LINE
- ===== CONCRETE WALL
- ..... INTERIOR WALL
- EXIST. BLDG. FOOT PRINT

## INDEX:

1. ZONE I ENTRY & EXIT
2. VEHICLE DECON.
3. ZONE II ENTRY & EXIT
4. SHIPPING OFFICE
5. TRUCK DOCK
6. WAREHOUSE
7. ALLOY KETTLE & CASTING MACHINE
8. REFINING KETTLES
9. SAN. BAG COLLECTOR
10. KIN BURNER BLDG.
11. KIN FURNACE METAL BAG HOUSE
12. BUFFER STORAGE BLDG.
13. DECASING DRYER
14. SETTLING BASIN
15. TRUCK DUMP STATION
16. TRUCK CUT
17. FUEL OIL TANKS
18. SLAG CRUSHER BLDG.



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FIGURE 1-2

In association with

ICF Inc. Jacobs Engineering, Inc. & Tetra Tech, Inc

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V. Reddy/J. Manfreda

NL Industries  
Pedricktown, NJ



In June 1989 the EPA confirmed the presence of highly reactive and hazardous materials in the facility warehouse. An additional funding was approved on September 1989 for removal and recycling of hazardous materials; warehouse building security; and encapsulation of four slag piles.

## **1.2 OBJECTIVES OF FEASIBILITY STUDY**

The objective of conducting a feasibility study (FS) was to identify feasible technologies and alternative approaches applicable to the removal of slag piles, other hazardous waste materials, process building decontamination, and standing water of the site. Based on the analytical results of the various waste streams, the identified technologies may be applicable for both on and off-site treatment. Additionally, the identification of remedial alternatives helps to evaluate the most cost-effective engineering solutions.

Specific goals of the FS included the following:

- a. Waste characterization (Section 2)
- b. Public health evaluation (Section 3)
- c. Treatment technology screening (Section 4)
- d. Evaluation of remedial action alternatives (Section 5)
- e. Comparative analysis of alternatives (Section 6)

## **2.0 WASTE CHARACTERIZATION**

A preliminary site investigation conducted in 1989 obtained one hundred and ten hazardous waste materials and seven water samples from five waste streams (slag piles, lead oxide piles, other hazardous waste areas, process buildings, and standing water) (Figure 2-1). The waste samples were collected in order to identify the nature of contaminants released at site. These samples were analyzed in accordance with the Contract Laboratory Program (CLP) protocol. The laboratory data from sampling are included in Appendix. Table 2.1 summarizes the analytical results of each waste stream. The five waste stream characteristics and laboratory results are discussed as follows:

### **2.1 SLAG PILES**

The slag piles consist of loose and dusty residual slag generated from the smelting and lead reclamation operations and stockpiled in outdoor bins. The four (4) piles (A, B, C, and D in Figure 2.1) were estimated to contain a volume of approximately 5,000 cubic yards.

A bituminous asphalt encapsulant (protective coating) was applied in April 1989, providing a protective coating to minimize airborne dispersion of dust particulates and rain water leaching of fines. Thirty one (31) samples were obtained from these slag piles and analyzed for elements from the Hazardous Substances List (HSL) inorganics. The analytical results are summarized in Table 2.1. The concentrations of iron and lead found in the slag piles ranged from 10,000 to 264,000 and 8,950 to 252,010 mg/kg respectively. The remaining HSL inorganic concentrations were lower in magnitude and found in all the samples.

## 2.2 LEAD OXIDE PILE











The waste material is found in piping, drums, tanks, piles, and the process and ventilation equipment in the buffer storage building (Figure 2.1). The Action Memorandum of ---- 1989, indicates that the lead oxides are located in the sweater furnace, clarifiers, filter drums, thickening tank and acid tank. The report also indicates that the lead oxide has high potential for contaminant release into the environment via airborne lead dust and surface water runoff due to the deterioration of the containers. Three (3) samples were obtained from these wastes and analyzed for HCL inorganics (see Table 2.1). The concentration of lead and iron found in these wastes ranged from 101,000 to 437,000 and 10,500 to 28,300 mg/kg. Cadmium, arsenic, aluminum, magnesium and antimony were also found in moderately higher concentration than remaining metals.

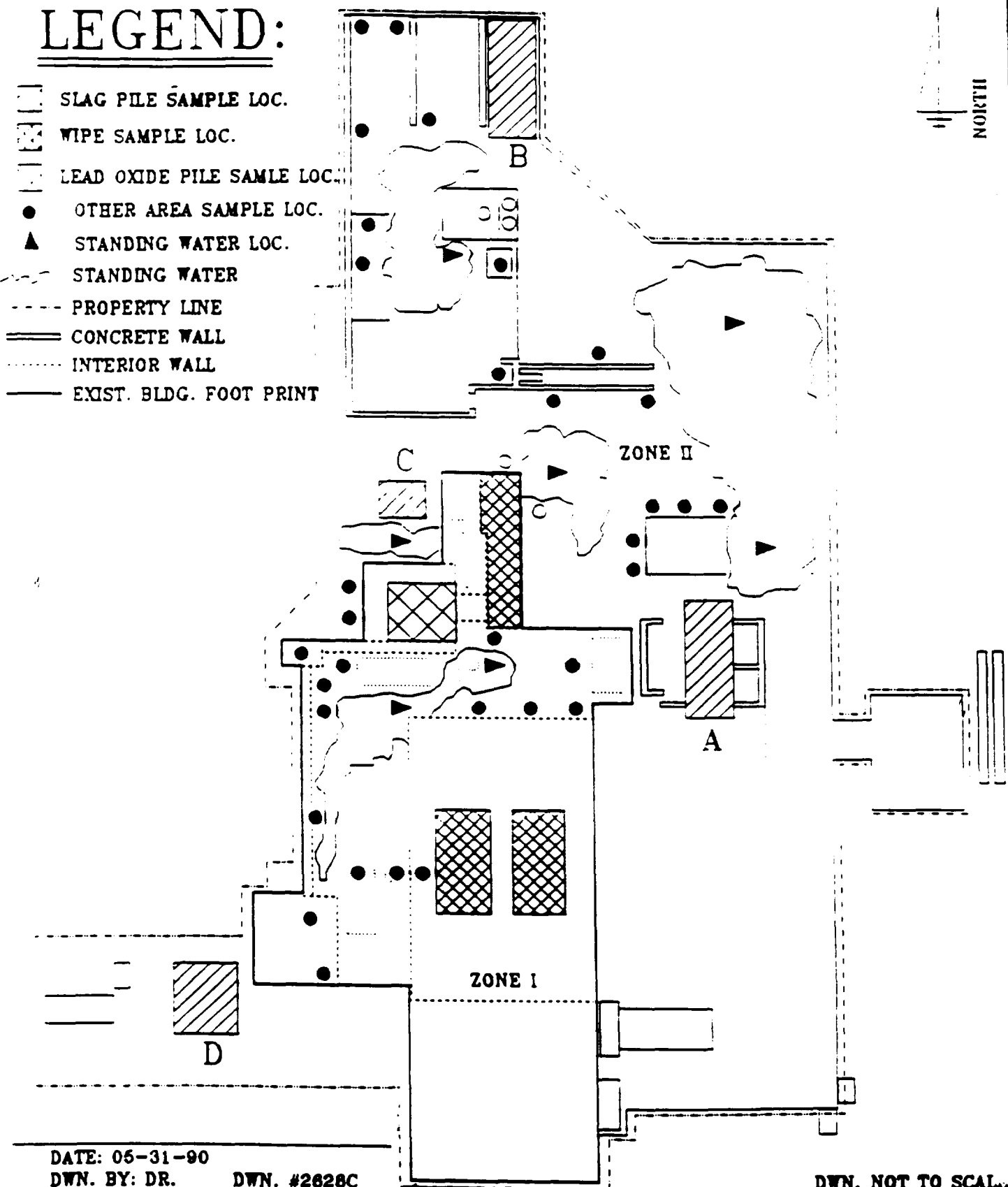
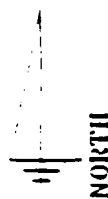
## 2.3 OTHER HAZARDOUS WASTE AREAS

There are numerous deteriorated empty drums, deteriorated drums with waste materials, fiber packs, dross (material skimmed), kiln slag, furnace bricks, scrap metal piles, feed stock, tyvek, battery material, and other debris materials scattered throughout the site. Fifty three samples were obtained from these areas. Lead and iron concentration levels found in the hazardous waste areas ranged from 531 to 60,500 and 141 to 34,900 mg/kg. The remaining HSL inorganics concentrations were 3 to 4 times, and sometimes even 5 to 6 times higher concentrations than the slag and lead oxide piles. The list of HSL inorganics and their concentration ranges are given in Table 2.1. Based on the analytical results, one can predict the relative threat to public health and the environment. A public health evaluation is presented in Section 3.0.

# WASTE STREAMS AND SAMPLE LOCATIONS

## LEGEND:

-  SLAG PILE SAMPLE LOC.
-  WIPE SAMPLE LOC.
-  LEAD OXIDE PILE SAMPLE LOC.
-  OTHER AREA SAMPLE LOC.
-  STANDING WATER LOC.
-  STANDING WATER
-  PROPERTY LINE
-  CONCRETE WALL
-  INTERIOR WALL
-  EXIST. BLDG. FOOT PRINT



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FIGURE 2-1

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Pedricktown, NJ

TABLE 2.1 SUMMARY OF CHEMICAL CONSTITUENTS IN DIFFERENT WASTE STREAMS  
NL Industries, Pedricktown, New Jersey

ESL INORGANICS		SLAG PILE *				LEAD OXIDE *	OTHER WASTE *	DECONTAMINATION *	STANDING **
		A	B	C	D	PILE	AREA	BUILDING WIPE SAMPLES	WATER SAMPLES
CAS No.	PARAMETER	MIN - MAX	MIN - MAX	MIN - MAX	MIN - MAX	MIN - MAX	MIN - MAX	MIN - MAX	MIN - MAX
7429-90-5	Aluminum	2180 - 20800	1010 - 5100	5000 - 8200	2370 - 9880	575 - 1210	15.4 - 16000	0.024 - 32.7	58.7 - 832.0
7440-36-0	Antimony	67.7 - 3040	123 - 19000	500 - 3150	47.4 - 2100	1490 - 2790	1.3 - 594000	0.0084 - 56.2	33.0 - 2080.0
7440-38-2	Arsenic	116 - 3580	224 - 842	877 - 1380	178 - 2910	293 - 614	0.8 - 38000	0.0009 - 17.4	8.0 - 80.0
7440-39-3	Barium	12.8 - 1560	13 - 474	742 - 2590	301 - 2930	10 - 220	0.15 - 11000	0.014 - 1.4	37.0 - 66.0
7440-41-7	Beryllium	1.5 - 6.9	2.5 - 7.2	4.4 - 10	1.2 - 9.3	0.55 - 0.65	0.011 - 14.9	0.0007 - 0.036	3.0 - 3.0
7440-43-9	Cadmium	39.5 - 359	22.4 - 271	162 - 1460	42.4 - 549	205 - 650	0.97 - 11300	0.0012 - 3.7	11.8 - 823.0
7440-70-2	Calcium	1560 - 8520	2510 - 14100	6020 - 8950	4270 - 14100	1550 - 3150	13 - 146000	0.063 - 91.2	3790.0 - 25900.0
7440-47-3	Chromium	51 - 640	165 - 1150	342 - 1440	218 - 7240	140 - 151	0.95 - 20000	0.0024 - 4.6	8.0 - 14.1
7440-48-4	Cobalt	11.1 - 268	33.5 - 300	29.1 - 96.4	8.1 - 103	4.3 - 9.8	0.07 - 183	0.0049 - 0.13	8.0 - 217.0
7440-50-8	Copper	430 - 8590	1350 - 7110	1410 - 4060	408 - 3090	132 - 674	2.1 - 14900	0 - 17	21.9 - 770.0
7439-89-6	Iron	32800 - 167000	68000 - 186000	129000 - 264000	10000 - 254000	10500 - 28300	141 - 349000	0.46 - 677	89.4 - 2420.0
7439-92-1	Lead	13500 - 193000	49600 - 252010	85700 - 226000	8950 - 151000	101000 - 437000	531 - 605000	0.88 - 552	160.0 - 4390.0
7439-95-4	Magnesium	612 - 13500	319 - 3860	791 - 2590	834 - 10100	253 - 1020	3.5 - 13900	0.24 - 9.9	1120.0 - 5170.0
7439-96-3	Manganese	149 - 1610	64.3 - 920	935 - 2030	237 - 1640	60.1 - 210	0.96 - 3290	0 - 5.5	14.7 - 328.0
7439-97-6	Mercury	0.065 - 0.71	0.069 - 0.76	0.08 - 0.26	0.072 - 0.16	1 - 1.6	0.034 - 64	0.0001 - 0.019	0.2 - 0.5
7440-02-0	Nickel	84.8 - 1070	137 - 635	538 - 1190	112 - 2620	138 - 342	1.4 - 3780	0.0087 - 5.2	14.0 - 343.0
7440-09-7	Potassium	2650 - 68400	5360 - 61800	17500 - 46300	6530 - 63700	11200 - 44800	101 - 66000	0.073 - 70	3160.0 - 10800.0
7782-49-2	Selenium	0.83 - 2.4	0.63 - 1.1	1.1 - 1.3	0.81 - 1.5	0.73 - 0.86	0.087 - 43.5	0.0007 - 0.084	5.0 - 50.0
7440-22-4	Silver	2 - 8.3	3 - 12	6.9 - 11	2.4 - 15	2.7 - 8.9	0.12 - 95	0.0024 - 0.37	7.0 - 9.0
7440-23-5	Sodium	2370 - 67500	5140 - 63100	19700 - 48700	5930 - 63900	12800 - 48600	61.9 - 69400	0.3 - 77.9	3430 - 698000
7440-28-0	Thallium	0.83 - 3.7	0.9 - 1.1	1.1 - 2.7	0.81 - 1.5	0.8 - 0.86	0.033 - 7.4	0.0009 - 0.003	6.0 - 6.0
7440-62-2	Vanadium	96.4 - 653	295 - 460	569 - 1630	117 - 554	9.4 - 17.3	0.61 - 785	0.0049 - 0.35	12.0 - 20.4
7440-66-6	Zinc	567 - 6830	1700 - 8420	1270 - 5680	696 - 7430	484 - 1430	25 - 69600	0.036 - 204	72.0 - 7230.0
	Cyanide							-	

\* UNITS - mg/kg

\*\* UNITS - ug/liter

## **2.4 WIPE SAMPLES FROM PROCESS BUILDING**

The process building walls, ceiling, floors, structural members, piping, process and ancilliary equipment (dust collectors, conveyors, and exhaust systems) are covered with dust. A total of twenty one (21) samples were obtained from the decasing dryer, refining kettles and casting machine buildings. The analytical data indicates high concentrations of lead, iron, cadmium, nickel, and copper metals throughout the building. Remaining metals such as aluminum, cobalt, arsenic, and vanadium were found in lower concentrations, probably in combination of lead-associated dust released from lead smelting operation. The HSL inorganics detected in the wipe samples are shown in Table 2.1.

## **2.5 STANDING WATER**

The standing water is runoff from precipitation. Water emanating from the slag piles was brownish-red in color and has contaminated areas within the plant. The standing water stored approximately 1 million to 1.5 million gallons. Seven (7) samples were collected (Figure 2.2). The samples were analyzed in accordance with CLP protocol. The concentration of lead and iron found in the water ranged from 160 to 4,390 and 89 to 2,420 micrograms per liter. Magnesium and potassium were also found in moderately higher concentrations than remaining elements. Table 2.1 summarizes the analytical results. The HSL parameters were detected in high concentrations in pooled areas and in low concentrations in non-pooled areas.

## **3.0 PUBLIC HEALTH EVALUATION**

The purpose of this Public Health Evaluation (PHE) is to assess the potential impact on public health and environment from the possible release of hazardous substances at the NL site. This baseline assessment evaluates the site in the absence of remediation and therefore, constitutes an evaluation of the no-action alternative. This study follows the guidelines established by EPA for removal action under the National Contingency Plan (NCP) Section 40 CFR 300.65(b) (2).

When NSNJ ceased smelting operations in 1984 the site was abandoned and a great deal of office equipment and laboratory chemicals, as well as other miscellaneous items, were left behind. These items attracted trespassers and many acts of vandalism and theft occurred until the chain link fence (described in Section 1.1) was erected.

The potential risks to human health associated with the NL site have been assessed based on the waste characterization described in Section 2.0. The analytical data attached in Appendix A indicates the presence of high concentrations of lead, arsenic, cadmium, barium and beryllium. These are the indicator chemicals which suggest a health and environmental risk based on toxicity

(Ref. 1986 b and 1986 c). The present conditions at the NL site meet the following criteria for a removal action under the NPL guidelines:

- o Actual or potential exposure to nearby populations, animals, or food chain by hazardous substances, (300.65 (b)(2)(i)).

The threat of direct contact is high, especially to trespassers entering buildings which contain hazardous waste materials.

- o Presence of hazardous waste material in bulk storage containers, slag and lead piles or other wastes that may pose a threat of release (300.65(b)(2)(iii)(v)). Most of the hazardous wastes stored or disposed of on-site are relatively stable. However, the chemical constituents in the slag piles even after encapsulation are known to be discharging into the environment. The airborne and stormwater run-off exposure pathways are considered to be the greatest threat to human health.

### 3.1 IDENTIFICATION OF EXPOSURE PATHWAYS

An exposure pathway consists of the following elements: (1) a source and mechanism of chemical release to the environment; (2) an environmental transport medium for the released chemical (e.g., air, surface runoff); (3) a point of potential human contact with the contaminated medium (referred to as an exposure point); and (4) a route of exposure at the exposure point (e.g., ingestion, inhalation, or dermal contact). The source of contamination have previously been identified as an air-borne and surface runoff resulting from the slag piles, other hazardous waste areas and standing water at the site. The following paragraphs address release mechanism, transport mechanism, potentially exposed populations and exposure routes relative to each of the potential exposure media - air, and surface runoff.

#### 3.1.1 AIR

Prior to the encapsulation of slag piles, the slag pile dust of ferrous sulphate and lead oxide were detected on the aluminium sidings of homes, automobiles, and etched concrete. The high concentration of lead, iron, cadmium, antimony were detected in the air-borne dust samples by NJDEP in ---- 1980. Therefore, the short-term encapsulation alternative on four slag piles might succeeded in reducing air releases.

Releases of contaminants to air may occur from wind erosion of slag piles and other hazardous waste materials at the site. The four slag piles were stored on-site in open bins and paved ground surface. Consequently, the potential for erosion of dusts by wind is high. The concentrations of lead, iron and other HSL inorganics detected in the residential and site vicinity are significant due to the airborne dust concentrations at potential downwind receptors.

### **3.1.2 SURFACE WATER**

Samples of standing water collected in November 1989 were found high contamination of lead, iron and other HSL inorganics. The contaminants of HSL inorganics are presented in the Table 2.1. The contamination in standing water is suspected of originating from an slag piles and other hazardous waste material discarded on the site. The bottom sediment in standing water and flooding water revealed off-site contamination due to the surface runoff from the hazardous waste materials are significant exposure pathways from the NL site.

### **3.2 DEVELOPMENT OF CLEANUP GOALS**

Under the Superfund Amendments and Reauthorization Act of 1986 (SARA), EPA is to consider maximum contaminant levels (MCLs) and maximum contaminants goals (MCLGs) developed under the Safe Drinking Water Act (SDWA), Federal Ambient Water Quality Criteria (AWQC), and National Ambient Air Quality Standards (NAAQS) to be potential Applicable or Relevant and Appropriate Requirements (ARARs) for use in risk assessment at superfund sites. The following remedial goal has been established based on the potential impact on public health and the environment posed by contaminants at the NL site. The goal is to eliminate or reduce airborne dust and hazardous waste material contaminants to acceptable risk-based levels.

The State of New Jersey recognizes both the importance of considering the relationships among various Federal and state regulations in setting cleanup levels, and the difficulty in applying any single set of criteria to all sites. Table 3-2 contains a list provided by the New Jersey Department of Environmental Protection (NJDEP), of all major potentially applicable state environmental regulations. Significant aspects of cleanup criterias are presented in Tables 3-1, 3-2 and 3-3.

TABLE 3-1 MAXIMUM CONCENTRATION OF CONTAMINANTS FOR  
CHARACTERISTICS OF EP TOXCITY

EPA Hazardous Waste Number	Contaminants	Maximum Concentration (mg/l)
D004	Arsenic	5.0
D005	Barium	100.0
D006	Cadmium	1.0
D007	Chromium	5.0
D008	Lead	5.0
D009	Mercury	0.2
D010	Selenium	1.0
D011	Silver	5.0

Source: 40 CFR 261 Sub part C 261.24 (b), 1985



TABLE 3-2 ECRA CONTAMINANT CLEANUP LEVELS REQUIREMENTS FOR  
HAZARDOUS WASTE SITE

Inorganic Constituents	Concentration in	
	Soil (mg/kg)	Ground Water (ug/l)
Antimony	10	-
Arsenic	20	50
Barium	400	1000
Beryllium	1	-
Cadmium	3	10
Chromium	100	50
Copper	170	1000
Lead	100	50
Mercury	1	2
Molybdenum	1	-
Nickel	100	-
Selenium	4	10
Silver	5	50
Thallium	5	-
Vanadium	100	-
Zinc	350	5000

Source: Environmental Cleanup Responsibility Act (ECRA)  
Guidelines, New Jersey Department of Environmental  
Protection, 1988.

**TABLE 3-3 NATIONAL INTERIM PRIMARY AND SECONDARY DRINKING WATER STANDARDS**

Contaminants	Primary (mg/l)	Secondary (mg/l)
Arsenic	0.05	-
Barium	1.0	-
Cadmium	0.01	-
Chromium	0.05	-
Copper	-	1.0
Iron	-	0.3
Lead	0.05	-
Manganese	-	0.05
Mercury	0.002	-
Selenium	0.01	-
Silver	0.05	-
Zinc		5.0
pH	-	6.5 - 8.5

Source: 40 CFR Part 141 Sub part B 141.11 (b) and Part 143.3,  
July 1985

#### **4.0 TECHNOLOGY SCREENING**

In this section, potential remedial technologies are screened for specific suitability under existing NL site conditions. In the initial identification process, appropriate technologies were sought which would address, by means of contaminant source control, potential health risks associated with direct contact. ~~Technologies for direct remediation of the five (5) waste streams~~ were considered. In addition, comparisons were made between technologies for on-site versus off-site treatment, and for removal (excavation) versus in-situ treatment. Each technology is described and its relative suitability evaluated according to the following criteria:

- o Areas of site to which applicable,
- o Technical considerations, and
- o Environmental/Institutional considerations.

Based upon these considerations, the technology was either retained for further consideration or eliminated. Relative cost estimates are given in Section 5. However, in accordance with SARA guidelines, cost alone is not used to eliminate technologies.

The technologies selected for evaluation are presented in Table 4.1.

#### **4.1 NO REMOVAL ACTION**

##### **4.1.1 DESCRIPTION**

Under this alternative, no further removal action would take place at the site. Contamination would be left in place. No changes in contaminant levels would be expected except those resulting from natural process (leaching and weathering). Site security upgrading would require improvements to the fencing around the site, including additional barriers and warning signs at the fence to discourage trespassing. Fence inspection and maintenance programs would be continued.

The security control measure would be improved to further restrict access. A monitoring program would be implemented to identify changes in site conditions over time and to warn of increasing exposures or health threats.

##### **4.1.2 AREAS OF SITE**

This technology is applicable to all areas of the site.

TABLE 4-1  
IDENTIFICATION OF FEASIBLE TECHNOLOGY TYPES AND PROCESS OPTIONS

	GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS
1.	No Remedial Action	Not applicable.	Not applicable.	No remedial action: long term surface, groundwater and air monitoring.	Potentially applicable.
2.	Excavation (slag and lead oxide piles and other waste materials)	Complete/Partial removal	None	Complete (all contaminated materials and hot spots) excavation/removal for the treatment.	Potentially applicable.
3.	Treatment (slag and lead oxide piles and other waste materials)	Thermal	In-Situ vitrification	Vitrifying slag and lead oxide at high temperature until it melts and procude rigid/glass like material.	Potentially applicable.
			Incineration/Roasting	Heating of slag and lead oxide piles and other waste materials at high temperature to minimize the waste for further disposal.	Potentially applicable
		Chemical	Extraction/waste material washing	Exposing waste material to solubilizing reagents, which results in retention of the waste in a fluid phase.	Potentially applicable
		Chemical	Hydro-metallurgical leaching process	This is the best treatment for extraction of heavy metals. A hot, aqueous caustic solution is allowed to leach through the waste, extracting the metals. The solution can be regenerated.	Potentially applicable.
			In-situ waste material flushing	Waste and soil materials saturated with selected reagents, which then percolate through contaminated materials, and then extracted. Contaminant laden wastes are treated for ultimate disposal or reinjection.	Potentially applicable.

TABLE 4-1 (continued)  
IDENTIFICATION OF FEASIBLE TECHNOLOGY TYPES AND PROCESS OPTIONS

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS
Treatment (building building decontaminated water and standing water)  Treatment (building decontamination and metal surface)	Physical/chemical	Stabilization/solidification	Utilizing mixing paddles and augers, a stabilizing agent is fed to the waste. This agent solidifies the waste. At the end of the process, the entire block of waste is set aside for curing and disposal.	Potentially applicable.
	Chemical	Ion exchange	Removes metals from wastewaters using an ion exchange resin	Potentially applicable.
	Chemical	Chemical precipitation and separation	Oxidizes metals and precipitates them from the wastewater into a solid form.	Potentially applicable.
	Chemical	Bleaching process	Chemically degrades contaminants on building walls and metal surfaces by using calcium hypochlorite to breakdown the contaminants and discharge them from the surface.	Potentiall applicable.
	Physical	Hydroblasting	High pressure water jet (3500 psi) is used to physically remove chemically breakdown contaminants from the surface.	Potentially applicable.

#### **4.1.3 TECHNOLOGY CONSIDERATIONS**

The no removal action/security upgrade alternative will not achieve the cleanup criteria, nor is it likely to result in significant reduction in exposure or health risk within the foreseeable future. Hazardous waste materials contamination will not be reduced except perhaps through leaching to groundwater. There are no significant technical considerations concerning the implementation of this alternative. This alternative will not assess future environmental concerns associated with the existing contamination.

#### **4.1.4 OTHER CONSIDERATIONS**

The no action alternative is the lowest cost alternative and requires continual monitoring for future commitment of resources.

#### **4.1.5 RECOMMENDATION**

Because this alternative represents straightforward monitoring, therefore, it was retained for future consideration.

#### **4.2 MINIMAL MITIGATIVE ACTION**

##### **4.2.1 DESCRIPTION**

Under the minimal mitigative action, remedial actions include, clearing drainage pathways, restaging contaminated debris, decontaminating the standing water, providing site monitoring, and upgrading site security.

Disengaging the drainage pathways are an important method of letting water drain off-site. Keeping pathways open is important to the site. Restaging of contaminated debris involves physically separating the material, decontaminating it by hydro blasting, and sending it off-site for recycling and/or disposal. The water used in hydroblasting will be collected into the standing water pool, and be treated with the rest of the standing water. The standing water can be treated using an ion exchange or chemical precipitation/separation process. See Section (4.13, 4.14, 5.8 and 5.9) for details.

The site will be monitored during this action. This monitoring will involve water sampling and air monitoring.

##### **4.2.2 AREAS OF SITE**

This technology is applicable to various areas of the site, including the contaminated debris and standing water pool.

#### 4.2.3 TECHNOLOGY CONSIDERATIONS

The minimal mitigative action alternative will result in complete decontamination of the standing water and possible decontamination of hazardous waste material. It will also allow for proper drainage around the site. It will not result in decontamination of the process buildings, removal of slag piles or remediation of the lead oxide piles.

#### 4.2.4 OTHER CONSIDERATIONS

The minimal mitigative actions is a relatively low cost alternative. It does not address the four slag piles. This alternative requires long term monitoring for future commitment of resources.

#### 4.2.5 RECOMMENDATION

Because this alternative addresses the standing water and physical clean-up of the site, it was retained for future consideration.

### 4.3 HAZARDOUS WASTE HANDLING

#### 4.3.1 DESCRIPTION

Hazardous waste handling involves the physical removal of hazardous waste materials. Once removed, the materials would be managed in such a way as to minimize or prevent their future contact with public health exposure and the environment. The extent of waste handling may range from selected areas of contamination to the entire site, depending on removal goals. For highly heterogeneous contaminant distributions, waste handling of the entire waste stream area would be necessary to ensure removal of contaminants. The highly heterogeneous and widely distributed contamination at the NL site would indicate that waste handling of the contamination may be treated (eg., waste material washing, hydro-metallurgical leaching process, in-situ vitrification) to remove contaminants for ultimate disposal or recycling.

#### 4.3.2 AREAS OF SITE

This technology is potentially applicable to slag and lead oxide piles and other hazardous waste areas of the site.

#### 4.3.3 TECHNICAL CONSIDERATIONS

Hazardous waste handling is a well-known technology which can be carried out with standard construction equipment. Because of the known heterogeneity of the waste materials, the waste handling effort will be complicated by the presence of particularly large and/or bulky objects such as furnace bricks, process equipment, metallic drums and other construction debris.

*Recubed  
refining  
around piles A, B, C, D*

The remedial investigation studies indicate that slag and lead oxide piles on-site range 5,000 cubic yards. In addition to waste handling the slag and lead oxide piles, it is likely that some waste handling of drums, fiber packs and other hazardous waste materials would be required. Determination of the eventual extent of waste handling will be require ongoing sampling as the hazardous waste handling proceeds.

Because this technology involves physical removal of contamination, it will result in permanent removal or reduction of the waste hazards of the NL site.

#### **4.3.4 OTHER CONSIDERATIONS**

Care must be taken during excavation and disposal operations to minimize off-site health and safety hazards. Safety measures may include dust control techniques and control of surface runoff. Seasonal weather conditions will affect the ease and cost of excavation operations.

While the technical feasibility of waste handling is reasonably clear, complications with the ultimate disposal of waste handled materials. Under the current RCRA landfill guidelines, reduction of contaminant concentrations must be reduced and EP toxicity criteria. From the standpoint of the NL site, hazardous waste handling technology presents great potential for permanently eliminating contamination sources.

#### **4.3.5 RECOMMENDATION**

This technology was retained for further consideration.

### **4.4 INCINERATION/ROASTING**

#### **4.4.1 DESCRIPTION**

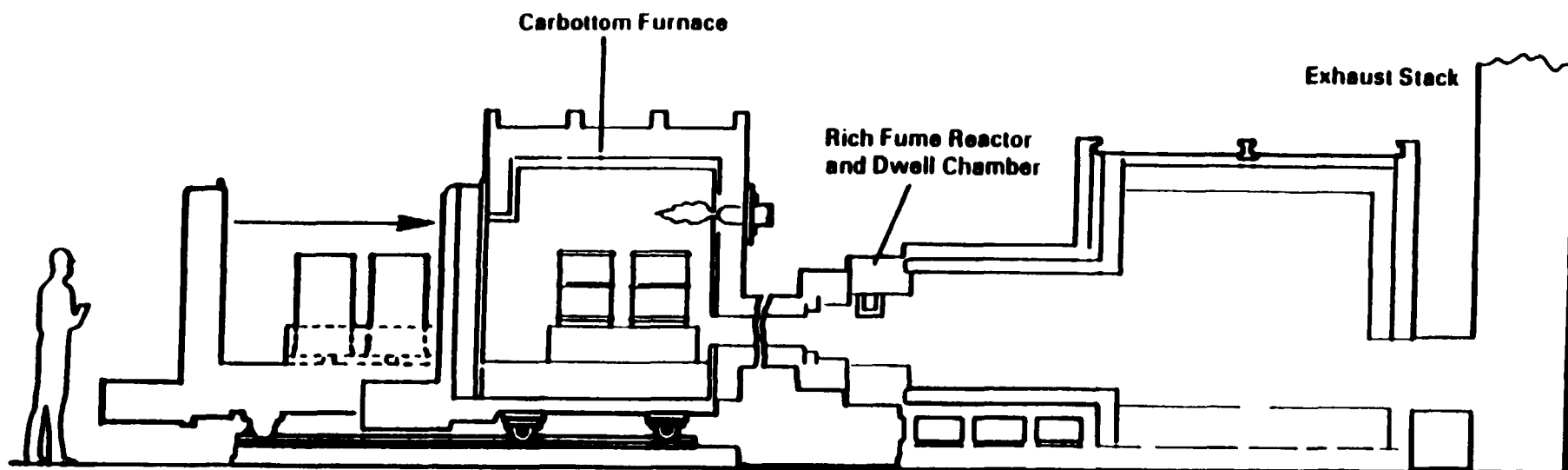
Incineration/Roasting has been investigated as a method of immobilizing heavy metals in waste materials. The wastes are heated to sintering temperatures and the metals are immobilized in slag for ultimate disposal. The residue may require the addition of some materials (such as kaolinite) to provide silicates for residue formation. The process can conceivably be conducted with modified rotary kiln incineration equipment (Figure 4.1).

#### **4.4.2 AREAS OF SITE**

This technology is potentially applicable to slag and lead oxide piles and other waste areas of the site.



# INCINERATION/ROASTING



SOURCE: Technology Screening Guide for  
Treatment of CERCLA soils & sludges



SPILL PREVENTION &  
EMERGENCY RESPONSE DIVISION

In Association with K F Technology Inc., C.C. Johnson & Associates,  
Inc., Resource Applications, Inc., Geo/Resource Consultants, Inc.,  
and Environmental Toxicology International, Inc.

EPA PM  
Eugene Dominach, OSC

TAT PM  
V. Reddy/J. Manfreda

FIGURE 4-1

NL Industries  
Pedricktown, NJ

#### 4.4.3 TECHNICAL CONSIDERATIONS

The process has not yet demonstrated reliability on a full scale basis for hazardous waste materials, and information on waste treatment (industrial slag, metals, sludges and dusts) is also limited. The process has been studied for the disposal of radioactive wastes. For wastes which have been studied, certain additives have sometimes been used to improve performance. Such materials include silica (kaolinite), sodium hydroxide, and iron oxide, and their combined effects are to decrease volatilization of metals and increase the viscosity of the melt, resulting in better capture of metals. The extent to which the waste materials at the site would require such supplementation requires further investigation.

The leachability of the immobilized metals should be quite low, therefore, RCRA landfill requirements will be met. However, hazards associated with direct exposure of aerosol during landfill of the slag are not known.

#### 4.4.4 OTHER CONSIDERATION

*What is the role of treatment possible (R. N.)*

The use of roasting and accessory devices discussed above are considered to be a proven technology for treating mixed wastes. Capital and operating costs for this alternative would likely be high. The stability of the byproduct or slag may facilitate on- or off-site disposal as a non hazardous material. Disposal volume may be higher due to the incorporation of silicate additives in the byproduct.

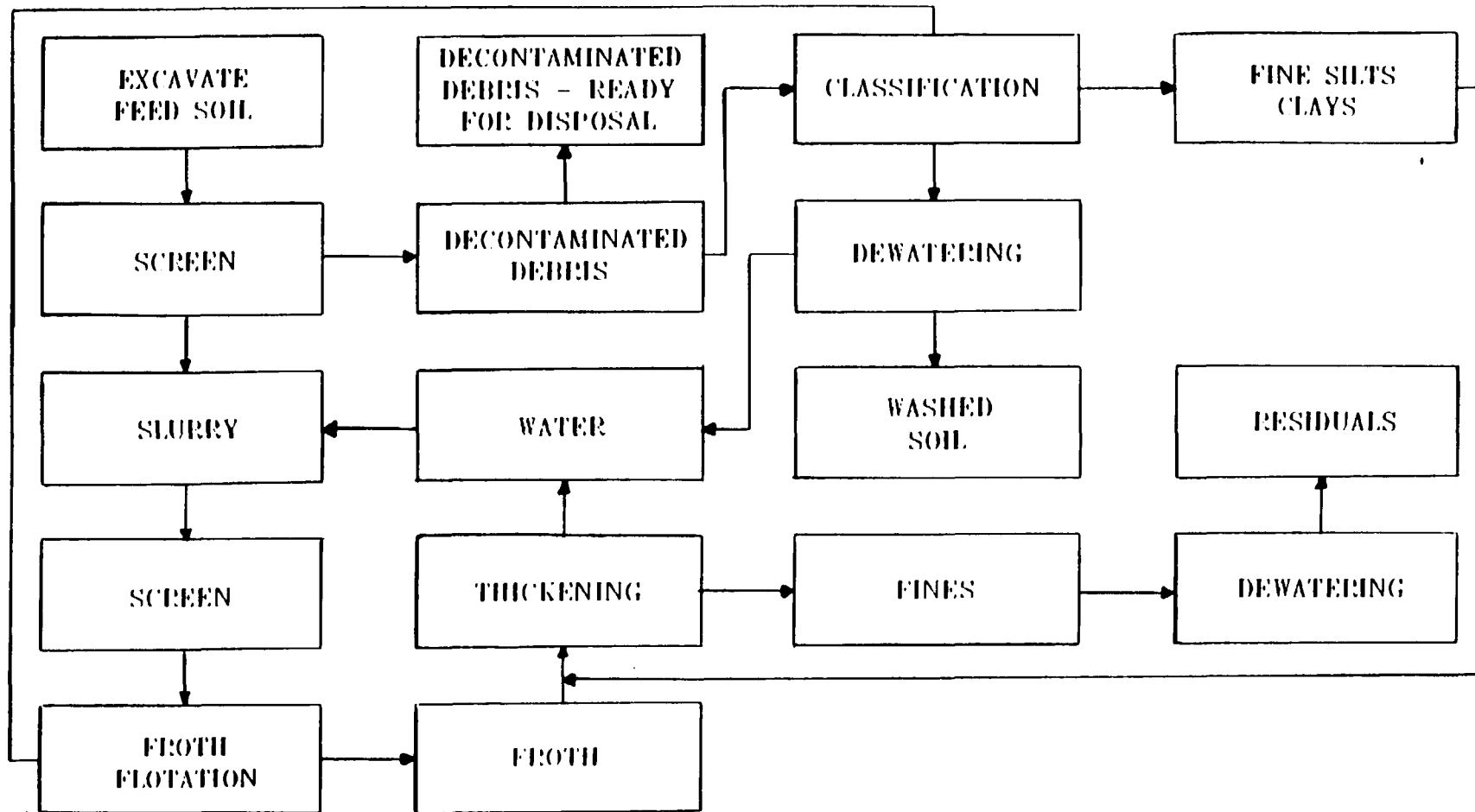
#### 4.4.5 RECOMMENDATION

Although unconventional, this technology relies upon relatively conventional equipment and will be retained for future consideration due to its potential for immobilizing metals.

#### 4.5 EXTRACTION/WASTE MATERIAL WASHING

##### 4.5.1 DESCRIPTION

Extraction refers to exposing the waste materials particles to reagents which result in the solubilization of waste chemicals and their retention in the fluid phase (Figure 4.2). For purposes of this discussion, the waste material wash operation refers to previously excavated waste materials (subsection 4.2), although conceptually similar processes may be feasible in-situ. Depending upon the efficiency of the extraction solution used, the washed waste may be deemed non-hazardous and disposed of on-or off-site. However, treated waste may still contain some low levels of contaminants. Management or treatment of the wash solution would be necessary.



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EPA PM

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V. Reddy/J. Manfreda

FIGURE 4-2

NL Industries  
Pedricktown, NJ

#### **4.5.2 AREAS OF SITE**

This technology is potentially applicable to slag piles and other hazardous waste areas of the site.

#### **4.5.3 TECHNICAL CONSIDERATIONS**

Reagent solutions which may affect various specific HSL inorganics include water, acids, caustics and some surfactants. Reagents of promise in removing metals include water, acids, and complexing agents such as EDTA or citrate buffer. Because of the number of HSL inorganic contaminants to be removed, a single reagent extraction may not be sufficient. Multiple steps may be required. Selection of a washing procedure would require a bench/pilot scale testing to determine reagents, removal efficiencies, and wastewater volumes generated. Because of the uneven distribution of wastes throughout the site, a number of site samples would have to be tested.

Certain components of the extraction reagents, such as inorganic acids or alkalis, may themselves be hazardous, or may complicate subsequent management of the resulting wastewaters. If the use of such reagents proves necessary, the relative benefits of this technology over others may require reexamination. Implementation of this technology at the NL site will require presorting of wastes to avoid damage to the equipment. Additional screening may be required as part of the wash process itself.

#### **4.5.4 OTHER CONSIDERATIONS**

Since certain exposure scenarios suggest that immobilization of wastes within the material may not adequately address perceived hazards (ingestion and inhalation), technologies which either destroy wastes or separate them from waste material warrant attention. Removal is required, and solvent extraction may be applicable, particularly for metals.

Potential extraction reagents range from water to relatively expensive reagents or contaminations thereof. The total cost of this particular technology may thus depend upon the results of the testing program. The reagents used for this alternative (as part of total cost) are not significant cost factors.

#### **4.5.5 RECOMMENDATION**

As one of the technologies that will remove metals from the waste, this option was retained for further consideration.

## **4.6 IN-SITU WASTE MATERIAL FLUSHING**

### **4.6.1 DESCRIPTION**

This technology refers to the in-situ extraction of contamination by water or aqueous reagents. The waste materials are saturated with the selected reagents, which then percolate through the contaminated materials to be reclaimed and extracted by a series of recovery systems/sumps developed for that purpose. The contaminant-laden waters are then treated by conventional processes for ultimate disposal or reinjection to the treatment process.

### **4.6.2 AREAS OF SITE**

This technology is applicable to slag piles and other hazardous waste areas the site.

### **4.6.3 TECHNICAL CONSIDERATIONS**

This in-situ waste material washing technology is conceptually similar to waste material washing (for excavated materials) and similar extractions would presumably be used to remove the various contaminants. As with waste material washing, multiple extraction steps/reagents may be required, and this multiplicity may be more difficult to implement in situ.

Since the waste material on this site is heterogeneous, the in-situ waste material washing technology may not be effective on this site because of the short contact time between the solvent/extraction solution and the waste material. In the application of the solution, it is likely that it will flow through the facility equipment, furnace bricks and other wastes that are indigenous to this site.

A critical consideration in the use of this technology is the correct placement of the recovery system/sump to ensure complete capture of the flushing agent and to prevent the increased transport of mobilized contaminants to surface runoff.

### **4.6.4 OTHER CONSIDERATIONS**

While this option may prove to be less expensive than excavation/washing, it is somewhat more difficult to predict the overall length of the remediation effort, as this would be assessed by continued sampling and ongoing assessment. Since costs accrue from the time of mobilization, a protracted program would likely diminish projected cost advantages.

#### **4.6.5 RECOMMENDATION**

The soil flushing option remains technologically and financially not feasible and was not retained for further consideration.

#### **4.7 IN-SITU VITRIFICATION**

##### **4.7.1 DESCRIPTION**

Vitrification is a technique for immobilizing contaminants in a glass-like or crystalline matrix by the application of heat. The resulting solid possesses excellent chemical durability. The process can conceivably be conducted in-situ by the insertion of molybdenum or graphite electrodes into the hazardous waste material in a grid pattern. A conductive material is arranged in trenches between the electrodes (see Figure 4.3). Application of electrical power results in progressive melting, first of the conductive material and then of the hazardous waste material itself, which becomes conductive as well. The process is continued until the desired zone has been melted. Power is then discontinued and the molten mass allowed to cool, entrapping metals and non-volatile components in the process. Any organic components present in the waste material are volatilized or pyrolyzed during the heating process and are burned or collected in an off-gas hood for further treatment. The process results in some volume reduction and, after cooling, the vitrified material can be disposed off-site. This process is still in the developmental stage.

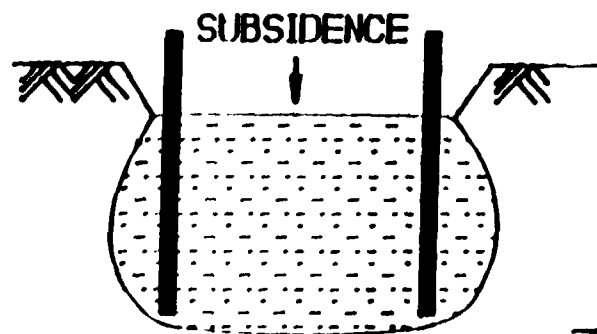
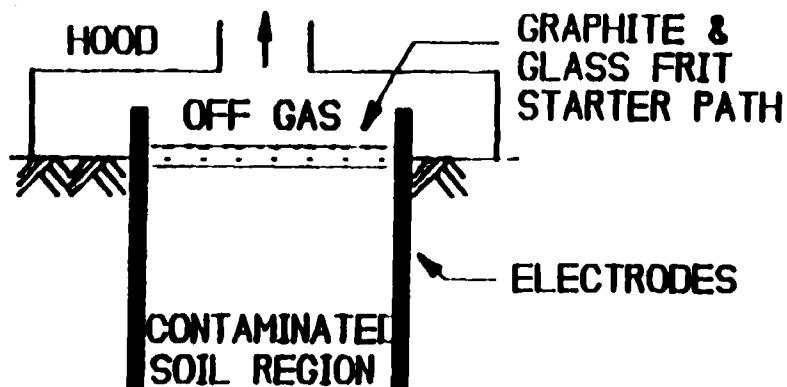
##### **4.7.2 AREAS OF SITE**

This technology is potentially applicable to slag piles and other waste materials, except for the standing water and process building decontaminated water on-site.

##### **4.7.3 TECHNICAL CONSIDERATIONS**

In-situ treatment technologies are inherently attractive because of reductions in material handling hazards and expenses. The technology, however, is compromised by highly heterogeneous contaminants and materials. Since the treatment mechanism in vitrification is heat, it may prove more capable of dealing with void spaces and discontinuities, particularly as progressive melting proceeds. At the same time however, it relies upon the presence of materials which melt and, upon cooling, solidify into crystalline materials. Such constituents presumably must be present in sufficiently large fractions as to incorporate the remaining contaminants into the solids. The technology may hold some promise. Its capability and suitability for the NL site would require investigation and demonstration.

# IN-SITU VITRIFICATION



SOURCE: Technology Screening Guide for  
Treatment of CERCLA soils & sludges

**WESTON**

SPILL PREVENTION &  
EMERGENCY RESPONSE DIVISION

In Association with ICI Technology Inc., C.C. Johnson & Associates,  
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FIGURE 4-3

NL Industries  
Pedricktown, NJ

#### **4.7.4 OTHER CONSIDERATIONS**

Assuming that the ability of the process to achieve melting and subsequent solidification of the waste (slag) materials can be demonstrated, the resulting product should prove to be a highly stable and permanent source control technique. Some safety hazards are associated with the process in terms of the high voltages used and the production of toxic gases during melting.

#### **4.7.5 RECOMMENDATION**

Because it is one of the few in situ technologies with the potential for addressing inorganic contamination and dealing with heterogeneous waste, this technology will be retained for further consideration.

### **4.8 STABILIZATION/SOLIDIFICATION**

#### **4.8.1 DESCRIPTION**

Stabilization technology, also known as solidification or fixation, is applicable to solid, liquid, or sludge waste. Solidification can be performed in situ, or in tanks or containers. In situ stabilization is achieved by a deep soil mixing technique. In situ stabilization allows direct application of stabilizing agents, utilizing mixing paddles and augers that blend the waste as a stabilizing agent is fed through the center of each shaft. At the end of treatment the treated block of mass or waste material is stored in curing areas for disposal (see Figure 4.4).

#### **4.8.2 AREAS OF SITE**

This technology is potentially applicable to slag piles and other waste materials of the site.

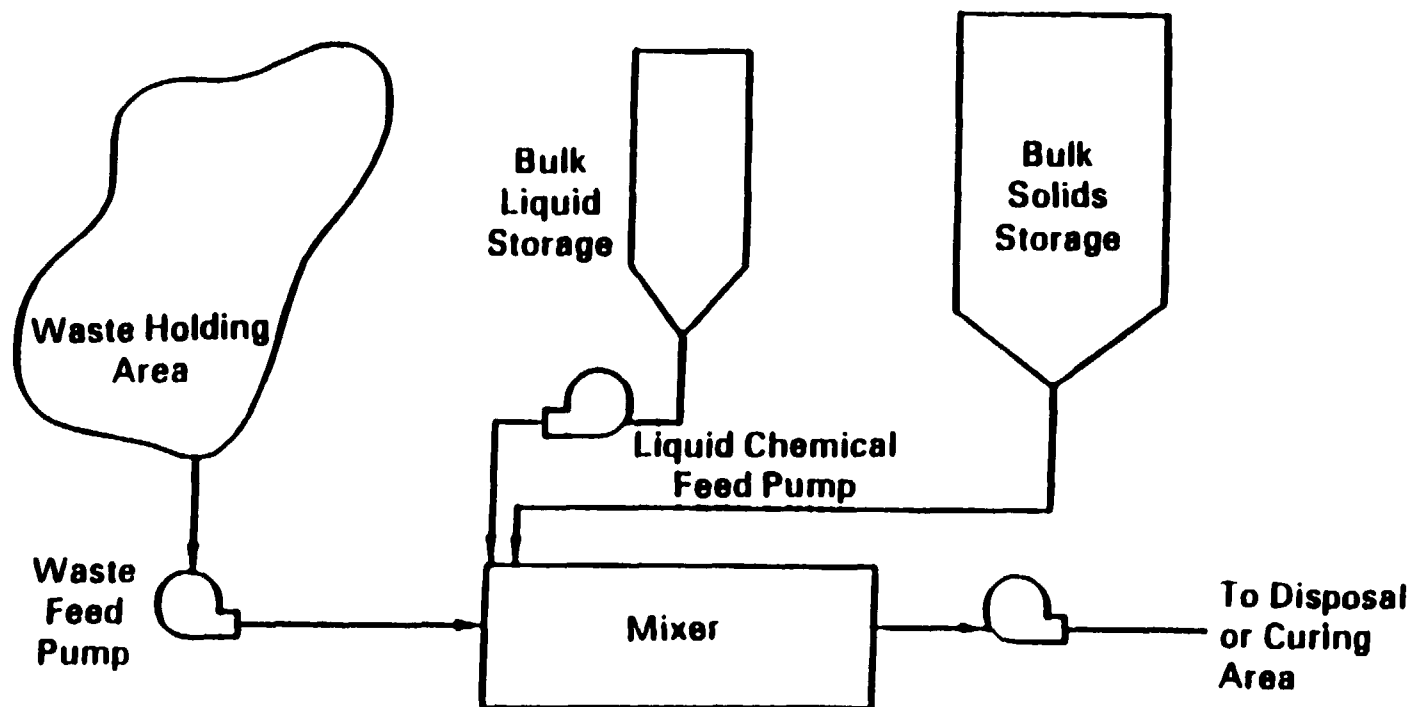
#### **4.8.3 TECHNICAL CONSIDERATION**

The stabilization/solidification technologies are inherently attractive because of the ease in handling of inorganic wastes. Before solidification, the waste material may be pretreated to adjust pH and to insolubilize heavy metals, thereby reducing their mobility. The high alkalinity of most cements and stabilizing agents will serve to neutralize acidic leachate, keeping heavy metals in their insoluble, less mobile form.

Whether applied in-situ or in tanks, stabilization facilitates a chemical or physical reduction of the mobility of metal constituents and forms a solid mass with low permeability that resists leaching. The actual mechanism of binding depends on the type of stabilization agent used: cement-based, pozzolanic- or silicate based, thermoplastic-based or organic polymer-based. On



# STABILIZATION/SOLIDIFICATION



SOURCE: Technology Screening Guide for  
Treatment of CERCLA soils & sludges



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FIGURE 4-4

NL Industries  
Pedricktown, NJ

a commercial basis, cement-based, asphalt-based, and pozzolanic-based techniques are more successful for treating inorganic wastes than the other techniques because of their wide range of applicability and use of less expensive reagents.

#### **4.8.4 OTHER CONSIDERATIONS**

Critical parameters in stabilization treatment include: selection of stabilizing agents and other additives; the waste-to-additive ratio; mixing and curing conditions. All of these parameters are dependent on the chemical and physical characteristics of the waste materials. Bench-scale treatability tests should be conducted to select the proper additives and their ratios, and to determine the curing time required to adequately set the waste. Leaching tests and comprehensive strength tests should be conducted to determine the integrity of the solid end product.

#### **4.8.5 RECOMMENDATION**

Because of the technology's popularity in handling of inorganic wastes, this technology was retained for further consideration.

### **4.9 HYDRO-METALLURGICAL LEACHING PROCESS**

#### **4.9.1 DESCRIPTION**

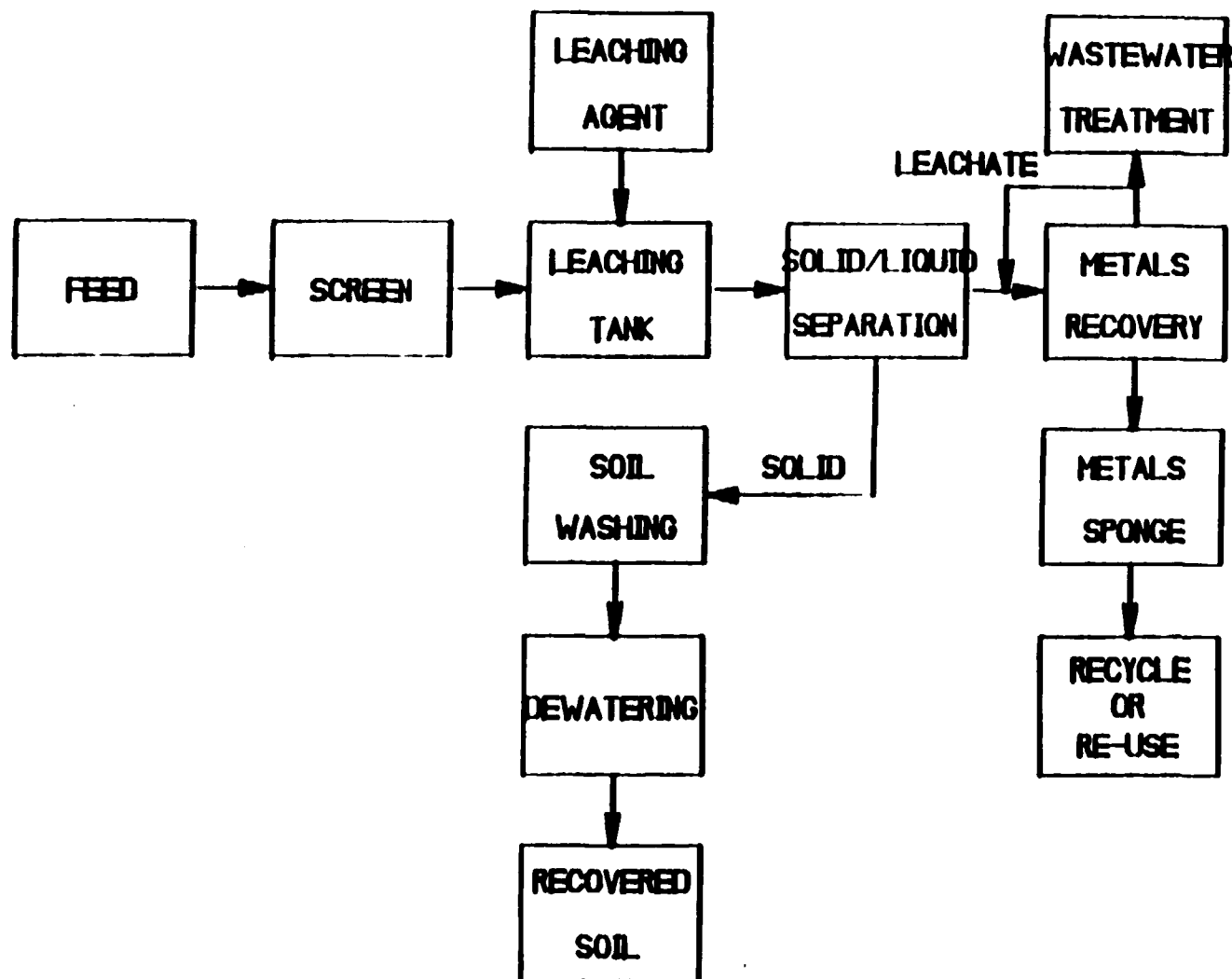
The hydro-metallurgical leaching process technology is based on the principles of hydrometallurgy commonly used for the extraction of metals from ores. This technique which uses a hot aqueous caustic leach solution is the best treatment strategy for the extraction of heavy metals from the waste residues. This solution can be regenerated after recovery of the dissolved metal values for subsequent leaching, thus minimizing reagent costs, reducing the waste volume and generating a saleable product from the existing toxic residues (Figure 4.5).

The selection of the technology is based on the ability of caustic solutions to efficiently extract oxidic lead compounds (lead oxide) from the complex residue assemblages, but not attacking the significant volumes of inert material present in the residues. An additional advantage is that lead metal may be recovered from the leach solutions in a precipitation reaction using a variety of reactive metals.

#### **4.9.2 AREAS OF SITE**

This technology is applicable to slag piles and other hazardous waste areas of the site.

# HYDRO-METALLURGICAL LEACHING PROCESS



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FIGURE 4-5

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#### 4.9.3 , TECHNICAL CONSIDERATION

The process involves leaching the residues in a caustic solution which selectively dissolves lead and other heavy metal impurities in the residues. The sodium, potassium, cadmium, and halogens (if any) contained in the residues also dissolve during the leaching step. These elements generally reside in water soluble compounds. Some lead compounds are resistant to this leaching process, for example, lead silicates generated during previous high temperature reactions. However, such compounds are extremely stable (such as lead bearing slag piles) and may not pose an environmental threat over any foreseeable future period of time regardless of the exposure they receive.

The leaching step is followed by filtration where the delead residue is separated and collected. The lead and halide rich leach filtrate is then reacted with metallic aluminum fines to precipitate the lead (and other dissolved metals) lower than aluminum on the electromotive series. The precipitate is a lead rich, saleable metallic sponge product. In doing so, the aluminum is solubilized as sodium aluminate, and a small amount of caustic is generated.

After a certain quantity of the spent solution is bled from the circuit, (to remove some of the remaining dissolved impurities) the solution is recycled. The bled solution is processed in a water treatment plant for separation and removal of residue metals. The recycle liquor must also be replenished with fresh caustic in accordance with leaching requirements.

#### 4.9.4 OTHER CONSIDERATIONS

The operating conditions (solution concentration, and leaching time and temperature) envisioned for the NL site will be a considerably more aggressive technology. In the NL case, the process strategy will be to dissolve all potentially soluble lead compounds including the associated cadmium, arsenic, and other heavy metals contaminants present. It is possible that a washed leach residue for the NL site will be completely being after treatment. Preliminary test results will confirm or deny the necessity of this step. The residue stabilization and disposal may increase the overall project costs. ?

#### 4.9.5 RECOMMENDATION

Because it is one of the few appropriate technologies with the potential of addressing inorganic contamination and dealing with heterogeneous wastes, this technology will be retained for further consideration.

#### **4.10 HYDROBLASTING METHOD**

##### **4.10.1 DESCRIPTION**

Hydroblasting involves the use of a high pressure (3500 psi) water jet to remove contaminated debris from applicable surfaces. The water is then collected in a sump, decontaminated, and sent to a treatment plant.

##### **4.10.2 AREAS OF SITE**

This technology is applicable to the de-casing building, an area with a large amount of debris.

##### **4.10.3 TECHNICAL CONSIDERATION**

The process consists of applying a high pressure water jet to the necessary area(s). The debris and contaminated water are collected in a sump where a solids separation takes place. The solids are separated by settling, and the water is recycled to storage tanks. A secondary decontamination may take place to remove any subsurface contamination (see Figure 4-6).

The hydroblasting process is attractive due to operational ease. This process allows for physical reduction in contamination of all affected areas. The main concern are noise of the process, clean-up of the waste water and worker safety. As a minimum, the suggested protective equipment includes; air purifying respirators, full-body protective suit, gloves, steel-toed boots, booties, and hard hat. Rain boots with non-slip soles should also be employed. If necessary, hearing protection may be used.

##### **4.10.4 OTHER CONSIDERATIONS**

The use of the hydroblasting procedure provides an excellent method for physical destruction of contaminants from all affected areas. This process will have to be repeated in order to clean the subsurface.

##### **4.10.5 RECOMMENDATION**

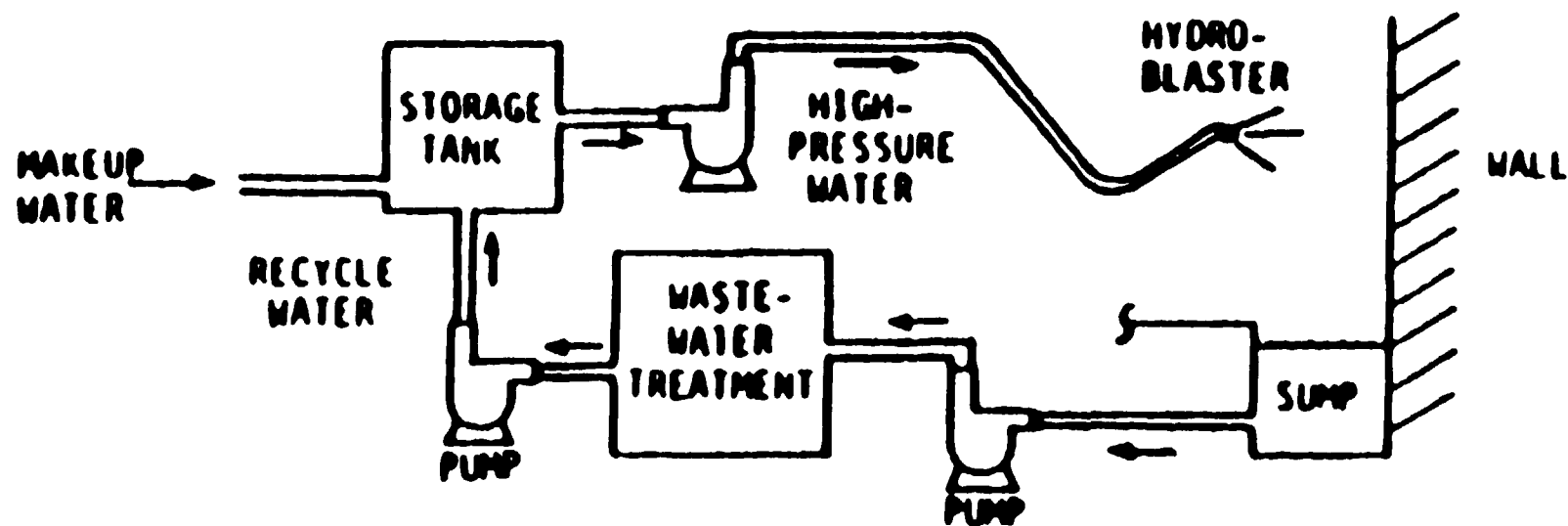
Because of the operational ease, this technology was retained for further consideration.

#### **4.11 BLEACHING PROCESS**

##### **4.11.1 DESCRIPTION**

As using a high pressure hose the bleach formula is sprayed on all contaminated surfaces. This procedure works best against metal, wood, concrete surface, and on large areas of contaminated building.

# SCHEMATIC DIAGRAM OF THE HYDROBLASTING PROCESS



SOURCE: Decontamination Techniques for  
Buildings, Structures and Equipment.

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FIGURE 4-6

NL Industries  
Pedricktown, NJ

#### **4.11.2 AREAS OF SITE**

This technology is applicable to the processing building and the equipment inside.

#### **4.11.3 TECHNICAL CONSIDERATION**

The bleaching method, which can be done on a large scale can be used to chemically degrade contaminants on metal surfaces, and With the use of a high pressure hose, this process can be done in a minimum amount of time and steps.

Various types of bleach formulations have been used as decontaminating agents. Traditionally, calcium hypochlorite has been used, although recently, sodium-based bleach formulations have had some application. The various bleaches used include Grades I, II, and III with >35 percent 29 to 35 percent, and <29 percent available chlorine; supertropical bleach (STB), a British formula containing >30 percent available chlorine; high test bleach (HTB), which has approximately 42 percent chlorine content; and liquid household bleach (sodium hypochlorite and sodium hydroxide).

The disposal of bleach is a major concern. Since a large quantity of bleach will be needed for an area of this size, a tremendous amount of contaminated bleach is produced. This bleach shall be pumped to a 50,000 gallon holding pool and will be properly treated before being sent to a treatment plant.

A critical consideration in the use of this process is worker safety. Each worker shall be equipped with an air purifying respirator, full body coveralls, impermeable foot cover, and hard hats. In addition, each worker shall have rainboots with non-slip soles.

#### **4.11.4 OTHER CONSIDERATIONS**

Critical parameters in this process include; selection of proper bleaching agents, proper stoichiometry, and all necessary hardware. A small scale treatment process test should be done to determine and select the proper agents and equipment, as well as treatment of contaminated bleach.

#### **4.11.5 RECOMMENDATION**

Because of the ease of application, this technology was retained for further consideration.

## **4.12 SOLVENT WASHING TECHNOLOGY**

### **4.12.1 DESCRIPTION**

In the solvent washing process, an organic solvent (hexane, pentane, or any other alkane solvent) is circulated onto the contaminated surface, attaching itself to the contaminant, and is forced out of the surface and into a filtering process. The solvent will then be chemically or thermally treated to remove the contaminant.

### **4.12.2 AREAS OF SITE**

This process is applicable to the wall of the processing building.

### **4.12.3 TECHNICAL CONSIDERATIONS**

This process involves a great amount of time for set-up and break-down. Depending upon the number of personnel, this time can last from several hours to several days. Personnel charges will be great for these two periods, but will be low for the actual process operation.

The disposal of the waste solvent is another concern. Since the targeted area is quite large, a tremendous amount of waste, approximately one million gallons (rough estimation), will be produced. This waste must be decontaminated and sent to a treatment plant (see Figure 4-7).

A critical consideration of this processes is worker safety. At a minimum, each worker shall have; an air purifying respirator, full body coverall, steel-toed boots, impermeable foot cover, gloves, and hard hat. In addition, each worker should have rain boots with non-slip soles.

### **4.12.4 OTHER CONSIDERATIONS**

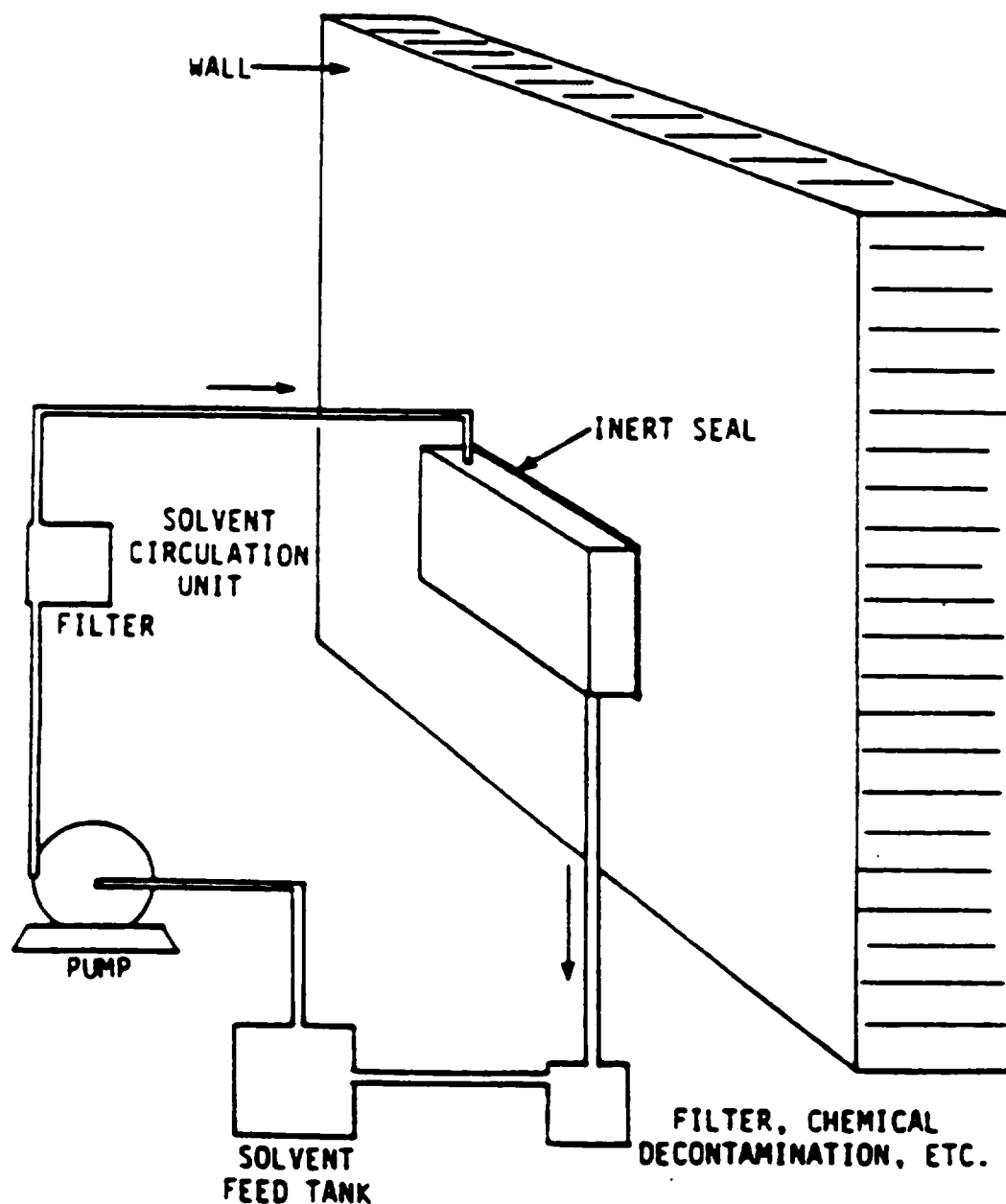
The cost for utilities and equipment will be moderate. A small scale test should be performed to determine feasibility of the process.

### **4.12.5 RECOMMENDATIONS**

The solvent washing process was not recommended because of the amount of intricate equipment in the targeted area, the need to move the "box" from one area to another, and due to the set-up and break-down time needed.



# SCHEMATIC DIAGRAM OF THE SOLVENT PROCESS



SOURCE: Decontamination Techniques for Buildings, Structures and Equipment.

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FIGURE 4-7

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#### 4.13 ION EXCHANGE

##### 4.13.1 . DESCRIPTION

Ion exchange is used to remove metals from aqueous hazardous wastes. After the metals are removed from the aqueous solution, the water can be discharged to the local publicly owned wastewater treatment plant, if it meets discharge requirements. The concentrated metal solution from the ion exchange resin can be recycled as product.

A brief description of the process is as follows; the waste stream is fed into an ion exchange unit, where metals are removed from the waste stream and are adsorbed onto the ion exchange resin in exchange for a cation. An example of this reaction is as follows:



Where Cu is a copper atom in solution, R is the ion exchange resin and H is the hydrogen atom exchanged in the resin.

The ion exchange resin can be regenerated using a strong acid run through the system, where metal will be removed from the resin into the acid solution. This solution can be disposed of or recycled and is considerably less than the original volume of liquid waste treated.

Ion exchange is applicable to the aqueous waste stream generated at the NL site. The metals found in the waste stream can be removed using an ion exchange resin. Sanitech, Inc. has a resin called DeVoe-Holbein compound which can operate at 99.99% plus removal efficiency of metal capture in both extremely high and low concentrations.

##### Efficiency of DeVoe-Holbein Compound

Target Metal	Untreated (ppm)	Treated (ppm)
Cd	674	<0.01
In	392	<0.01
Ni	352	<0.01
Cu	381	<0.01
Cr	312	<0.01
Fe	335	<0.01
Co	353	<0.01
Pb	1243	<0.01
Hg	1204	<0.05
Ag	647	<0.01

#### **4.13.2 AREAS OF SITE**

The ion exchange technology can be used to treat the standing water and the water from the building decontamination process. Sanitech may also donate equipment for treatment of the wastes to examine the potential of their ion exchange unit to treat hazardous wastes. Lab scale treatment studies and pilot plant tests will be necessary to determine if the technology can treat the site's aqueous waste in theory as well as in the field.

#### **4.13.3 TECHNOLOGY CONSIDERATIONS**

This section will discuss the DeVoe-Holbein process for technology considerations as it is a ion exchange unit with the same features and characteristics as all ion exchange units (see Figure 4-8).

First, wastewater is pumped into a surge tank. This tank is used to store waste water and provide a constant flow of untreated water to the ion exchange unit and prevents intermittent functioning.

The untreated water is then pumped through a flowmeter and/or flow totalizer. Next, the water is transported to the top of the ion exchange column. Multiport valve heads spread the wastewater across the top of the column. The aqueous waste flows downward over the ion resin and the metals are removed from the solution. The treated water can then be discharged to a sewer if it satisfies compliance limits. Constant sampling of the effluent will determine if it is within the limits.

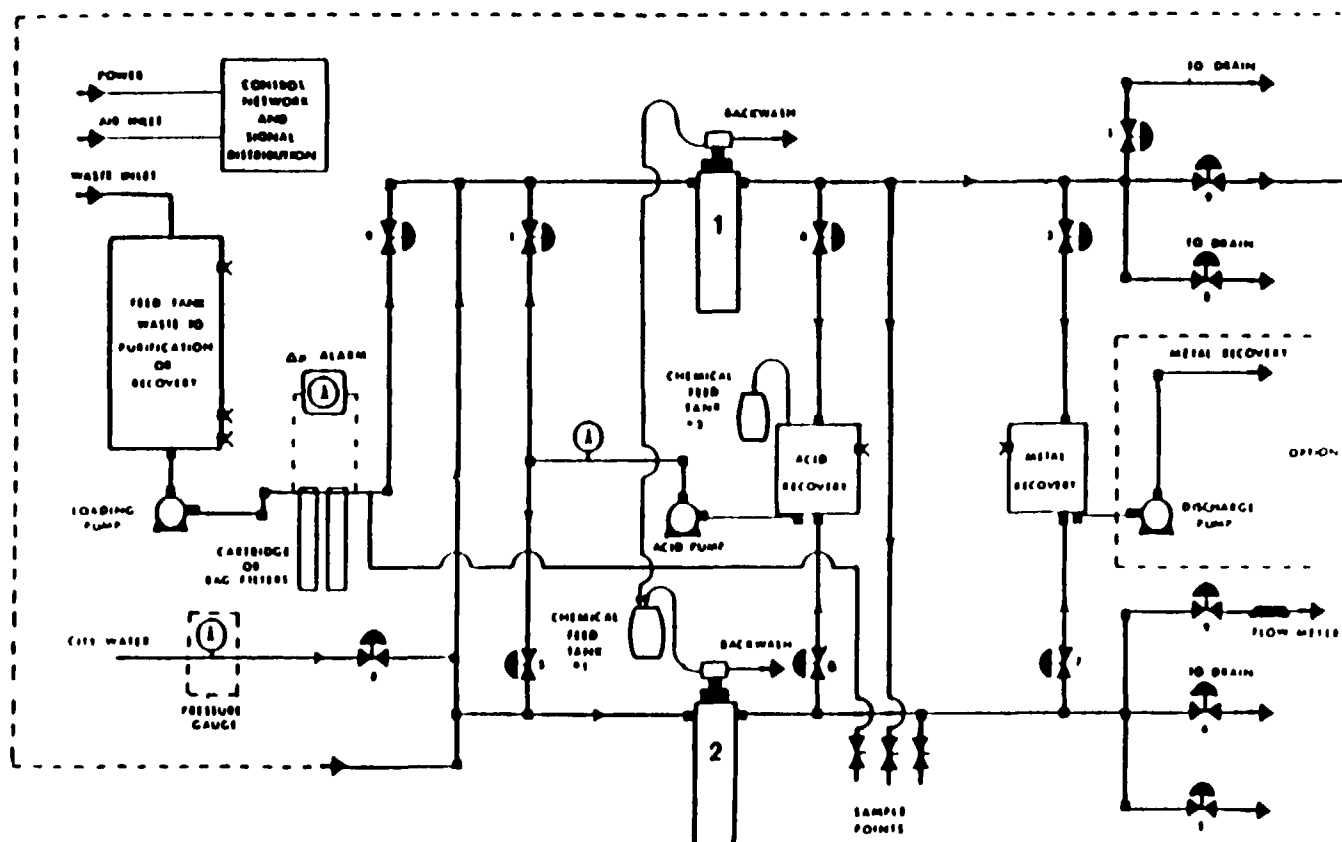
When the ion exchange resin can no longer function it must be regenerated. The first step is to backwash the column with water, removing all the solids which have been filtered out by the column. The next step is to circulate an acid in the column to remove all the metals in the resin. For the DeVoe-Holbein process, the volume of acid solution necessary to remove all the metals from the resin is usually 1/3 the bed volume. After the acid solution is removed from the column, the ion exchange resin is ready to treat wastewater again.

#### **4.13.4 OTHER CONSIDERATIONS**

The DeVoe-Holbein ion exchange resin has limitations such as high concentrations of metals in the solution. A solution for this problem is to add another column to meet discharge requirements. Another limitation is the ion exchange columns may be prone to fouling by some organic substances. This problem can be solved by backflushing the system to clean the column of fouling materials.

# PROCESS FLOW SCHEMATIC

TYPICAL { DH-1 to 3D  
DH-4D } 2 COLUMNS SERIES FLOW



SOURCE: DeVoe-Holbein (Canada) Inc.



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FIGURE 4-8

NL Industries  
Pedricktown, NJ

#### **4.13.5 RECOMMENDATIONS**

The Sanitech ion exchange technology will be considered for further studies.

#### **4.14 CHEMICAL PRECIPITATION AND SEPARATION**

##### **4.14.1 DESCRIPTION**

Chemical precipitation is a process by which metals are oxidized in solution and then precipitated to form a solid metal oxide. The solids can be removed by settling and/or filtration. Chemical precipitation has been used to treat liquid wastes containing arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium and zinc. Effluent metal concentrations of less than 1 mg/l and sometimes less than .1 mg/l are achievable. Industries and facilities that use chemical precipitation include the metal plating and polishing industries, steel and nonferrous metals industries, mining, electronics manufacturers, landfills leachate treatment facilities, publicly owned wastewater treatment works, and hazardous waste sites having metal contaminated wastes as leachate or contaminated groundwater.

##### **4.14.2 AREAS OF SITE**

This technology can be used to treat the standing water on-site and the waste water from the contamination of the buildings at the National Lead site.

##### **4.14.3 TECHNOLOGY CONSIDERATIONS**

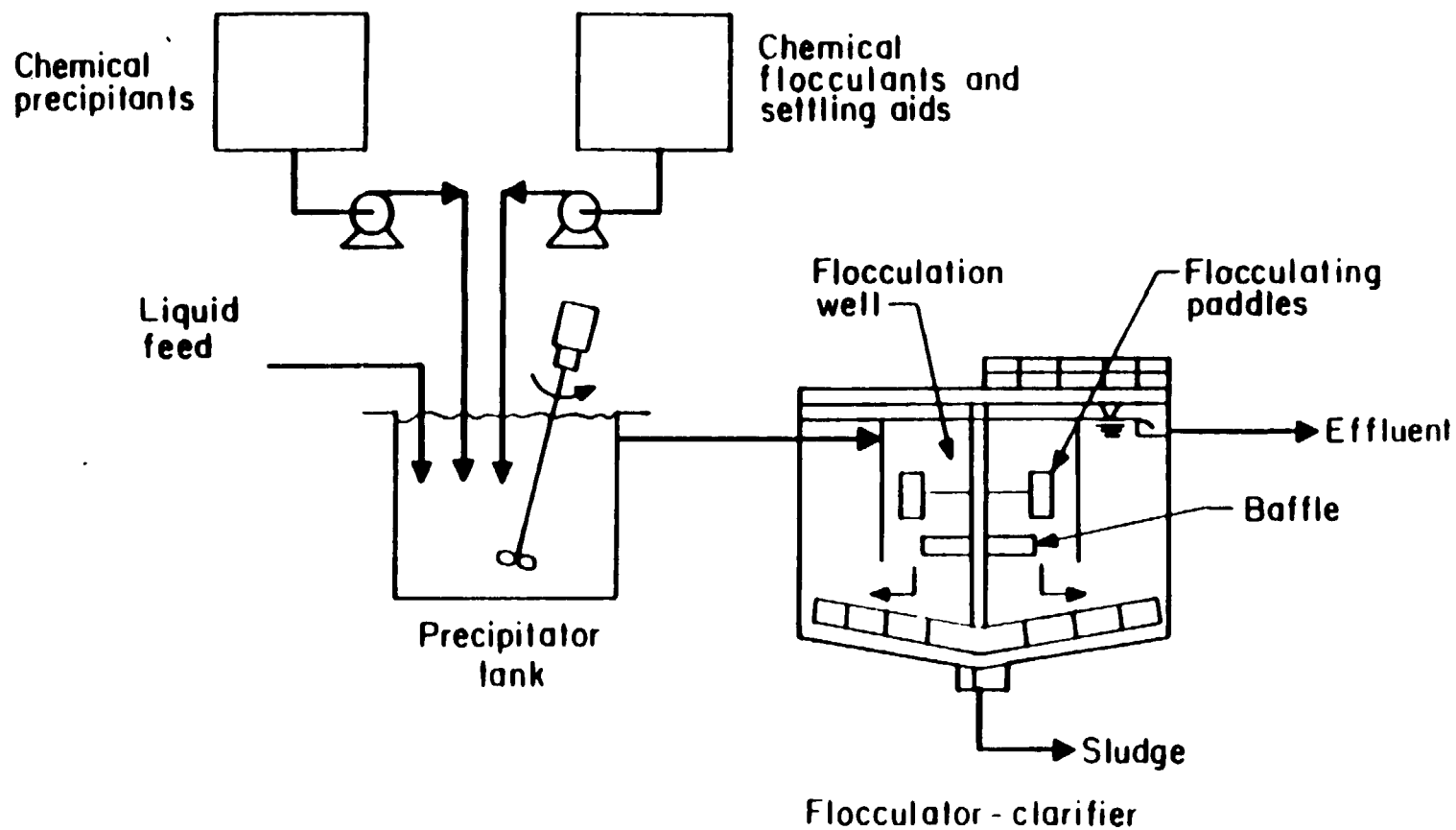
The process equipment needed for chemical precipitation is usually a mixing tank, a settling tank and a filter. A process flow diagram is shown in Figure 4-9. The metal containing stream is fed into a mixing tank with chemical precipitants, flocculants and settling aids. The contents of the mixing tank are continuously pumped to a settling tank, which has mixing baffles and paddles. Treated water is pumped from the top of the tank and sludge is taken from the bottom of the tank. The sludge is further treated by filtering out water with a filter press. The de-watered sludge can then be disposed of and the water from the filter press recycled back into the mixing tank.

The treated water from the settling tank can be discharged into a local sewer.

##### **4.14.4 OTHER CONSIDERATIONS**

A chemical precipitant must be selected for the process. Commonly used precipitants are lime (calcium hydroxide), caustic soda (sodium hydroxide), sulfides, sodium carbonate, and sodium borohydride, with lime and caustic soda being the more popular.

# CHEMICAL PRECIPITATION PROCESS DIAGRAM



Source: Standard Handbook of Hazardous Waste Treatment and Disposal



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FIGURE 4-9

NL Industries  
Pedricktown, NJ

Problems with chemical precipitation are as follows: The pH of minimal solubility varies with each metal, in most cases being between 9 and 11. For wastes containing several metals, several precipitation stages may be required to remove all the metals to desired levels or another precipitant may be required.

There is no cyanide problem associated with the waste. Cyanide in the waste stream acts as a complexing agent, which inhibits precipitation. Cyanide can be pretreated to destruction using alkaline chlorination, with the products being carbon dioxide and nitrogen.

Hexavalent chromium cannot be treated directly by the commonly used process of hydroxide precipitation. The chromium must first be reduced to a trivalent state, using a reducing agent, such as (a low pH) sulfur dioxide.

The heat of reaction in the mixing tank can cause localized splashing and the unwanted release of solution vapors. It is important that the design of the equipment include a method to either cool the reactor or dilute the waste stream before entering the mixing tank if it is necessary.

Since the standing water contains various metals, testing will be necessary to determine if chemical precipitation can meet discharge requirements. Bench scale jar tests determine this and optimum pH, settlability of precipitants, settling aid requirements, and aid in the design of custom equipment.

#### **4.14.5 RECOMMENDATION**

Chemical precipitation will be considered for treatment of the standing water and water from the decontamination of the buildings. Past studies indicate this technology will effectively treat these wastes.

#### **4.15 SUMMARY**

Based upon this technology screening process, the following remedial technologies have been retained for consideration. The feasibility of appropriate combinations of these technologies as complete remedial alternatives will be developed in the following section.

- o Hazardous Waste Handling;
- o Incineration/Roasting;
- o Chemical extraction;
- o Extraction/Waste material washing;
- o In-situ waste material flushing;
- o In-situ vitrification;
- o Stabilization/Solidification;
- o Hydro-metallurgical leaching process;
- o Hydroblasting method;
- o Bleaching process; and
- o Ion exchange process

## **5.0 EVALUATION OF REMEDIAL ACTION ALTERNATIVES**

### **5.1 BACKGROUND**

#### **5.1.1 DEVELOPMENT OF ALTERNATIVES**

Remedial action alternatives for effecting the cleanup of the NL site are outlined and evaluated in this section. Based upon the existing site characterization (sample analysis results) and the technology screening process, several alternatives were developed to address both site-specific remediation goals (cleanup criteria) and the objectives and requirements of SARA.

The remedial action alternatives detailed below were based on remedial goals and appropriate remedial technologies which are described in Section 4.

- o Non-Cost Criteria

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- State acceptance
- Community acceptance

- o Cost Criteria

- Capital cost
- Operating and maintenance costs, and
- Ongoing (monitoring) costs in the post remediation phase

#### **5.1.2 SITE SPECIFIC CONSIDERATIONS AND REMEDIAL APPROACH**

Briefly stated, the remedial action goals (cleanup criteria) arising from the public health evaluation are the following:

- o Eliminate, or reduce to acceptable risk-based levels, waste contaminants which present potential public health threats via direct exposure to the contaminated materials. The contaminants judged to pose such risks include lead and barium;
- o Eliminate, or reduce to acceptable risk based levels, air and surface water contaminants which represent potential public health threats due to the long term exposure pathways (air and surface water run-off). Contaminants are concern include iron, cadmium, arsenic, copper, beryllium, antimony and chromium.



Ideally, complete source control measures should, in the long term, result in significant improvements in exposure pathways. Properly implemented source control technologies should however, eliminate or significantly reduce the impact of this particular source of contamination.

The site remedial approach is based on the results of the sample analysis, which demonstrated widely dispersed and highly variable results in physical characteristics of waste materials. The highly heterogeneous nature of the waste material at NL site dictates that the cleanup philosophy to remediate the site requires on-site or off-site disposal of all the listed waste streams.

### 5.1.3 GENERAL WASTE CONSIDERATIONS

Contaminants of concern at the NL site are primarily the heavy metals. The following general considerations apply to the selection of remedial alternatives for these wastes:

- o Many in-situ remedial alternatives, such as those which flush contaminants from the waste or entrap contaminants, are compromised by the high degree of heterogeneity of the waste. This heterogeneity is likely to interfere significantly with the even and consistent application of remedial technologies in-situ. For example, soil flushing is likely to be compromised by the tendency for flushing solutions to follow voids and channels created by the waste materials and thus fail to contact all wastes;
- o A variety of technologies exist for treating materials once they are removed from the site. These alternatives involve extensive materials handling, including extensive pre-sorting, screening and/or shredding steps. Most options/or alternatives also result in the production of certain hazardous residues for off-site disposal/treatment, and;
- o Stabilization and incineration/roasting technologies, and those treatment processes which leave low levels of residuals in the end products (treated waste) might reasonably be expected to reduce surface water contamination as well as elimination of air pollution from the site.

Efforts were made to select technologies which represent the various ranges of options. For example, at least one in-situ process was considered for comparison to excavation and treatment options. Additionally, at least one stabilization/solidification option was considered for comparison with removal/destruction options.

#### 5.1.4 COST EVALUATION

Conceptual level (preliminary) cost comparisons were developed for each remedial alternative based upon preliminary specifications derived from RI studies. To the extent practicable, those costs were derived from conventional engineering estimating procedures. Costs include capital plus operating and maintenance costs. For options in which untreated wastes are to be left in place, operating (monitoring) and maintenance costs were considered over a 30 year period, coinciding with RCRA requirements for post-closure monitoring. For options in which wastes are to be removed for off-site disposal, monitoring was projected for five years after the completion of the remedial phase. However, for certain technologies performance (such as case study examples) are not available because of the preliminary stage of technology development. These technologies background information were obtained from several companies. The relatively speculative nature of these estimates must be considered in evaluation of overall projected costs.

#### 5.2 ALTERNATIVE 1 - NO REMOVAL ACTION

Under the no removal action alternative at the NL site, no additional steps would be implemented beyond those already in place, as a result of the 1989 response action. This action includes the following steps:

- o Up grade site security;
- o Periodic site monitoring, and

However, continued maintenance of those measures, as well as surveillance of site conditions, should proceed. Major aspects of those programs would include:

- o Regular site inspections aimed particularly at site security, the integrity of site structures (fences and encapsulation), and the physical integrity of the site surface;
- o Continued maintenance of security measures, primarily the site fence, based upon continuing evidence of trespassing.
- o Annual sampling of on-site monitoring surface runoff to document water quality.

Although designated as a no removal action alternative, in that no remedial steps are taken with respect to the wastes remaining on-site, this alternative does include maintenance of the existing fence (which has been subject to damage). In addition to this a annual surface runoff water sampling is also included to help detect any significant change in conditions.

### **5.2.1 NON-COST CRITERIA**

#### **5.2.1.1 TECHNICAL CONSIDERATIONS**

Since no waste material will be implemented, technical feasibility is not an issue. The major technical concern with this alternative, as implied above, concerns the interpretation of surface water runoff monitoring data in the potential presence of on-site sources, the degree to which that data will be effective in detecting and evaluating increased risk.

#### **5.2.1.2 INSTITUTIONAL CONSIDERATIONS**

The following institutional considerations apply to this alternative:

- o The existing control strategies at the site do not meet RCRA criteria for contaminant and control of contaminants;
- o Under SARA guidelines measures which do not meet applicable requirements may be applicable under limited number of situations, such as surface water monitoring;
- o Public opposition should be expected under this alternative, since no reduction in environmental impacts would result. This opposition may be heightened because of the proximity of the site to housing and schools.
- o Adoption of this alternative results in the commitment to a long-term, although relatively straightforward maintenance.

### **5.2.2 COST CRITERIA**

Operation and maintenance cost for the no removal action alternative is presented in Table 5-1.

As indicated in this table the major cost components of this alternative is the monitoring requirements resulting from leaving the waste materials in place. This would result in total cost of approximately \$351,300.

## **5.3 ALTERNATIVE 2 - MINIMAL MITIGATIVE ACTION**

### **5.3.1 DESCRIPTION**

This alternative involves minimal mitigative actions include, clearing drainage pathways, restaging contaminated materials such as scrap metal piles, tyvack, furnace bricks, fiber packs, drums, dross, facility equipments, and other debris, and also decontaminating the standing water.

TABLE 5-1

ALTERNATIVE 1 - PRELIMINARY ESTIMATE OF TOTAL COSTS --  
NO REMOVAL ACTION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1	Security Inspection, quarterly, 8 hrs/quarter	32 hr.	70/hr	\$ 2,240
2	Surface water Monitoring (Annual)			
	o Labor: sampling (8 hours per cycle)	32 hr.	70/hr.	\$ 2,240
	o Analytical: metals plus blank/duplicate	6 samples	1200/ea	\$ 7,200
	o Expenses: sampling	Lump sum	1000	\$ 1,000
3	Maintenance			
	o Fence repair	500 ft/yr	6/ft	\$ 3,000
	o Vegetation Control, annual	15,000 s.y.	0.30 s.y.	\$ 4,500
4	Reporting/Documentation			
	Engineering report preparation, 8 hrs./quarter	32 hr	70/hr	\$ 2,240

(continued)

TABLE 5-1

ALTERNATIVE 1 - PRELIMINARY ESTIMATE OF TOTAL COST --  
NO REMOVAL ACTION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
5	Subtotal			\$ 22,420
6	Administrative (25%)			\$ 5,605
7	Contingency (25%)			\$ 5,605
8	Annual Total (rounded)			\$ 33,630
9	Present worth*			\$351,300/year for 30 years

\*Assumes 30 years maintenance (wastes left in place)

Implementation of the minimal mitigative action involves several separate operations:

- o Physical separation of contaminated debris, i.e., deteriorated drums, fiber packs, furnace bricks, scrap metals, and process equipment to a specific area of the site;
- o Decontamination of the debris, and separating contaminant from remainder of the debris;
- o Disposal or recycling of decontaminated debris;
- o Decontamination of the standing water, either by an ion exchange treatment or a chemical precipitation and separation method;
- o Clearing pathways on-site to provide drainage of water.
- o Removal of standing water bottom sediment and dispose into the slag piles.

After completion of minimal mitigative action, the ongoing surface water and air monitoring program would be implemented to document water and air quality. This monitoring program would serve to identify potential changes in environmental impacts arising from changing site conditions.

#### **5.3.2 NON COST CRITERIA**

##### **5.3.2.1 TECHNICAL CONSIDERATIONS**

The minimal mitigative action involves technologies that are dependent on the waste material exposed on the site, which involves a great deal of physical labor. The standing water will be treated either by an ion-exchange, or a chemical precipitation and separation method (techniques description see sub section 4.13 and 4.14). The contaminated debris will be treated with the bleach/hydroblasting technique and disposed for recycling. Should sampling prove that some of the waste streams has not been significantly decontaminated, the process may be repeated until contamination levels meet acceptable disposal/recycling criteria (see Tables 3-1 and 3-2).

##### **5.3.2.2 INSTITUTIONAL CONSIDERATIONS**

The following institutional considerations apply to this alternative:

- o The existing control strategies at the site do not meet RCRA criteria for contaminants and control of contaminants;

- o Under SARA guidelines measures which do not meet applicable requirements may be applicable under surface water monitoring;
- o Public opposition should be expected under this alternative, since elimination of slag piles from the site would not be addressed. This opposition may be heightened because of the proximity of the site to housing and schools;
- o Adoption of this alternative results in the commitment to a long-term, although relatively straightforward maintenance;
- o Local discharge of treated water (effluent) will require an NPDES permit or local sewer discharge approval.

#### **5.3.2.3 PUBLIC HEALTH AND ENVIRONMENTAL ISSUES**

The following public health and environmental issues should be considered:

- o Since this alternative will result in decrease in amount of contaminants, it will prove effective in minimizing future threats for the public health and welfare arising from the NL site;
- o Surface water runoff and air monitoring will be performed during this action, to ensure omissions do not exceed accepted levels.

#### **5.3.3 COST CRITERIA**

A breakdown of costs for this alternative are given in Tables 5-2 and 5-3.

### **5.4 ALTERNATIVE 3 - HAZARDOUS WASTE HANDLING/WASTE MATERIAL WASHING**

#### **5.4.1 DESCRIPTION**

This alternative involves hazardous waste handling of waste materials followed by a waste washing process to separate contaminants from the waste materials and residue leaving a product sufficiently decontaminated to permit off-site disposal. Information for this alternative has been developed in part through literature provided by vendors, ECOVA corporation, GSX Services, WASTE TECH Services, and BIOTROL, Inc.

TABLE 5-2

## ALTERNATIVE 2 - PRELIMINARY ESTIMATE, CAPITAL COST -- MINIMAL MITIGATIVE ACTION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1	Drainage Clearance			
	o Restaging large debris, drums and equipment on site.	4,000* c.y.	225/c.y.	\$ 900,000
	o Standing water treatment before disposal	1 million gallons*	Lump Sum	\$ 250,000
	o Sediment handling	200* c.y.	225/c.y.	\$ 45,000
2	Engineering/oversight personnel through Implementation Phase (2 month) (2 persons)	1,000 hr.	70	\$ 70,000
3	Subtotal			\$1,265,000
4	Contingency (25%)			\$ 316,250
5	TOTAL (rounded)			\$1,581,250

(continued)

\*\* Rough estimated value, based on site visit on May 17, 1990.



TABLE 5-3

ALTERNATIVE 2 - PRELIMINARY ESTIMATE OF OPERATION AND MAINTENANCE COSTS --  
MINIMAL MITIGATIVE ACTION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1	Security Inspection, quarterly, 8 hrs/quarter	32 hr.	70/hr.	\$ 2,240
2	Surface water monitoring (Annual)			
	o Labor: sampling (8 hrs. per quarter)	32 hr.	70/hr.	\$ 2,240
	o Analytical: metals plus blank/duplicate	6 samples	1200/ea.	\$ 7,200
	o Expenses: sampling	Lump sum	1000	\$ 1,000
3	Maintenance			
	o Fence repair	500 ft/yr	6/ft	\$ 3,000
	o Vegetation Control, annual	15,000 s.y.	0.30 s.y.	\$ 4,500
4	Reporting/Documentation			
	Engineering report preparation, 8 hrs./quarter	32 hr	70/hr	\$ 2,240

(continued)

TABLE 5-3

ALTERNATIVE 2 - PRELIMINARY ESTIMATE OF OPERATION AND MAINTENANCE COSTS --  
MINIMAL MITIGATIVE ACTION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
5	Subtotal			\$ 25,420
6	Administrative (25%)			\$ 6,355
7	Contingency (25%)			\$ 6,355
8	Annual Total			\$ 38,130
9	Present worth (rounded)*			\$1,725,800/year for 30 years

\*Assumes 5 years maintenance (wastes left in place)

The waste material washing (extraction) alternative is presented in Figure 4-2. This figure shows the technology process and treated waste material. Waste staging would occur near the facility area (paved surface) of the site. The specific location of the waste material wash process should be selected to facilitate discharge of the wash solutions. Implementation of this alternative would involve the following major operations:

- o Removal of other waste areas, to the treatment facility area;
- o Handling of slag piles and contaminated soils;
- o Staging of handled (excavated) materials in a cleared areas of the site;
- o Pre-sorting for removal of large debris and restage debris for decontamination. Debris removal is required to avoid damage to equipment;
- o Screening/mechanical shredding to achieve uniform small fragments;
- o Processing of shredded waste in waste material in waste material wash equipment;
- o Treatment of wash streams by appropriate technology (such as ion exchange or chemical precipitation and separation). Wash water will be recycled to the wash process, with concentrate/regenerant stream to disposal;
- o Sampling of washed materials to verify adequacy of treatment, and
- o Off-site disposal of washed materials to off-site disposal.

Should the sampling program indicate that contamination in some fraction has not been sufficiently reduced, recycling of feed material may be required until the cleanup criteria should be achieved. In order to minimize the likelihood of such event, a bench scale test, followed by a pilot testing program should be conducted to demonstrate the suitability, performance, and economics of this technology. However, the pilot testing program would be necessary for a limited number of samples for the washed materials.

## **5.4.2 NON COST CRITERIA**

### **5.4.2.1 TECHNICAL CONSIDERATIONS**

Soil wash process employ, technologies derived from the mining and enhanced oil recovery business for the actual separations, of contaminants from soils and conventional water treatment technologies for treating the wash waters. The primary technical uncertainty to address during pilot testing, appears to be the process effectiveness in dealing with the highly heterogeneous waste materials. Existing literature indicates excellent removals from the contaminants of concern at the NL site. However, the effectiveness of the process in achieving contact with all heterogeneous waste materials may require additional investigation.

The process will likely result in relatively small weight and volume reductions in the washed materials (on the order of 40% for contaminated waste material washing) that would generate 60% volume of treated waste for off-site disposal.

The process will result in a volume of final discharge wash water for further treatment that will be suitable for discharge to sewers. Remaining technical uncertainties with respect to necessary extraction solution from dross, facility equipment and other material, the effectiveness of the process must be addressed in a pilot test program.

Based on material processing rate and pre-wash materials handling requirements, the implementation phase of this technology is expected to last 1 to 1.5 years.

Implementation of this process involves several relatively complex unit operations, including pre-sorting and shredding, the wash process itself, the recovery and treatment of the wash solutions, and the need for testing of residual materials prior to disposal. The applicability of all of these steps to the types of wastes at the NL site must be examined in the pilot program.

### **5.4.2.2 INSTITUTIONAL CONSIDERATIONS**

The following institutional considerations apply to this alternative:

- o Treated wastes may retain some low concentrations of contaminants and the wash solutions (solvents) which may leach out in the future;
- o The off-site disposal of treated materials must be the requirements of the cleanup criteria. This treatment should approach the stated goal of reducing toxicity and/or volume of wastes considered for off-site disposal;

- o Off-site disposal of pre-sorted debris, treatment process concentrate streams, and any unsuccessfully decontaminated wastes will require compliance with Federal and State DOT requirements for handling, transport, and tracking of hazardous wastes. With conventional wash water treatment systems such as ion exchange, precipitation and separation or flocculation and filtration, residue concentration streams may be high and disposal of these volumes can add to the cost;
- o Local discharge of final, treated, wash waters will require an NPDES permit or local sewer discharge approval.

#### **5.4.2.3 PUBLIC HEALTH AND ENVIRONMENTAL ISSUES**

The following public health and environmental issues should be considered:

- o Since this alternative will result in removal of contaminants from the site, it may prove effective in minimizing future threats to public health and welfare arising from the NL site. However, the performance of the system clean-up goals should be demonstrated prior to implementation;
- o Depending upon the contaminants and the solvents used, air (vapor) emissions from the process may have to be examined.

#### **5.4.3 COST CRITERIA**

Cost evaluation for implementation of this alternative is presented in Tables 5-4 and 5-5. While the soil wash process has been used at a limited number of installations, it is not yet appropriate to consider it a conventional technology, and the cost for its application to the NL site may still be somewhat speculative.

### **5.5 ALTERNATIVE 4 - IN-SITU VITRIFICATION TREATMENT**

#### **5.5.1 DESCRIPTION**

This alternative employs an innovative soil treatment technology, vitrification, in an attempt to achieve adequate containment or treatment of containments with the requirement for excavation of the waste and subsequent on-site burial or off-site disposal and associated operations. Potential savings in time and expense, and reductions in operating hazards to be gained by eliminating these operations must be evaluated against potential total implementation/operating costs and uncertainties associated with the vitrification process. Since the process is still in an early stage of development, projected costs are somewhat uncertain.

TABLE 5-4

ALTERNATIVE 3 - PRELIMINARY ESTIMATE, CAPITAL COST --  
HAZARDOUS WASTE HANDLING/WASTE MATERIAL WASHING

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1	Waste Handling			
	o slag piles,	5,000 c.y.	5.00/c.y.	\$ 25,000
	o standing water bottom sediment	200 c.y.	6.00/c.y.	\$ 1,200
2	Presort debris, equipment and drums for future treatment restaging	4,000 c.y.	16.00/c.y.	\$ 64,000
3	Soil Wash (9,200 cy = 6,210 tons)			
	Laboratory evaluation and process development			
	- Laboratory scale	Lump sum		\$ 20,000
	- Pilot scale	Lump sum		\$175,000
	o mechanical shredding, 15 ton/hr (to avoid equipment damage and increase contact between solvent and contaminants)	Lump sum 6,500 tons	20/ton	\$130,000

TABLE 5-4

ALTERNATIVE 3 - PRELIMINARY ESTIMATE, CAPITAL COST --  
HAZARDOUS WASTE HANDLING/WASTE MATERIAL WASHING

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
	Waste material wash process, o includes treatment/recycle of wash solution and disposal, approximately 100 cy/day	9,200 c.y.	100/c.y.	\$920,000
4	Disposal of treated material o testing of washed material, one sample per 500 cy. Sample and analysis for VOA/BNA/metals (incl. blanks)	20 samples	1,200 ea.	\$24,000
5	Grading/Vegetation	2 ac	10,000	\$20,000
6	Water supply for waste material* wash process	500 loads	500/load	\$250,000
7	Engineering/oversight personnel through implementation in phase (4 persons, one year each)	10,000 hr	70/hr	\$700,000
8	Subtotal			\$2,329,200
9	Mobilization/Demobilization (30%) Construction management, site services			\$698,760

(continued)

\* Assume 2 loads/day i.e., approximately 20,000 gallons/day.

TABLE 5-4

ALTERNATIVE 3 - PRELIMINARY ESTIMATE, CAPITAL COST --  
HAZARDOUS WASTE HANDLING/WASTE MATERIAL WASHING

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
10	Technology Implementation, designs, plans, specifications, regulatory approval, insurance bonds, permits (30%)			\$698,760
11	Overhead and Profit (10%)			\$232,920
12	Contingency (25%)			\$582,300
13	TOTAL (rounded)			\$4,542,000



TABLE 5-5

ALTERNATIVE 1 - PRELIMINARY ESTIMATE, CAPITAL COST --  
HAZARDOUS WASTE HANDLING/WASTE MATERIAL WASHING

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1	Security Inspection, quarterly, 8 hrs.	32 hr.	70/hr	\$ 2,240
2	Surface water Monitoring (Annually)	8 hr	70/hr	\$ 2,100
	o Analytical: metals plus blank duplicate	6 samples	1200/ea	\$ 7,200
	o Expenses: annual	Lump Sum	1000	\$ 1,000
3	Maintenance			
	o Fence repair	500 ft/yr	6/ft	\$ 3,000
	o Vegetation Control,	15,000 s.y.	0.30 s.y.	\$ 4,500
4	Reporting/Documentation			
	Annual engineering report preparation	40 hr	70/hr	\$ 2,800
5	Annual Total (rounded)			\$ 22,840
6	Present worth*			\$4,598,800/year for 3 years

\*Assumes 3 year maintenance, post remediation, removal phase takes 1 year.

Furthermore, application of the process (which has been primarily investigated) the treatment of metal and radioactive contaminants would require investigatory and pilot studies, and the cost and time required for this development work should be considered.

The treatment to be achieved by in-situ vitrification (ISV) consists of immobilization of metals within a crystalline matrix, and volatilization, followed by combustion/oxidation of organic (if any). The actual performance of the process in capture or destruction of metals must be demonstrated prior to implementation.

Implementation of this alternative involves the following steps. A generalized diagram of the process is presented in Figure 5-1.

- o Excavation of slag and lead oxide piles and other waste areas;
- o Selection of suitable on-site area for waste material vitrification and excavate suitable size vitrified area;
- o In-situ vitrification of contaminated fill area, extending into waste materials disposed in vitrified area, and
- o Grading and revegetation.

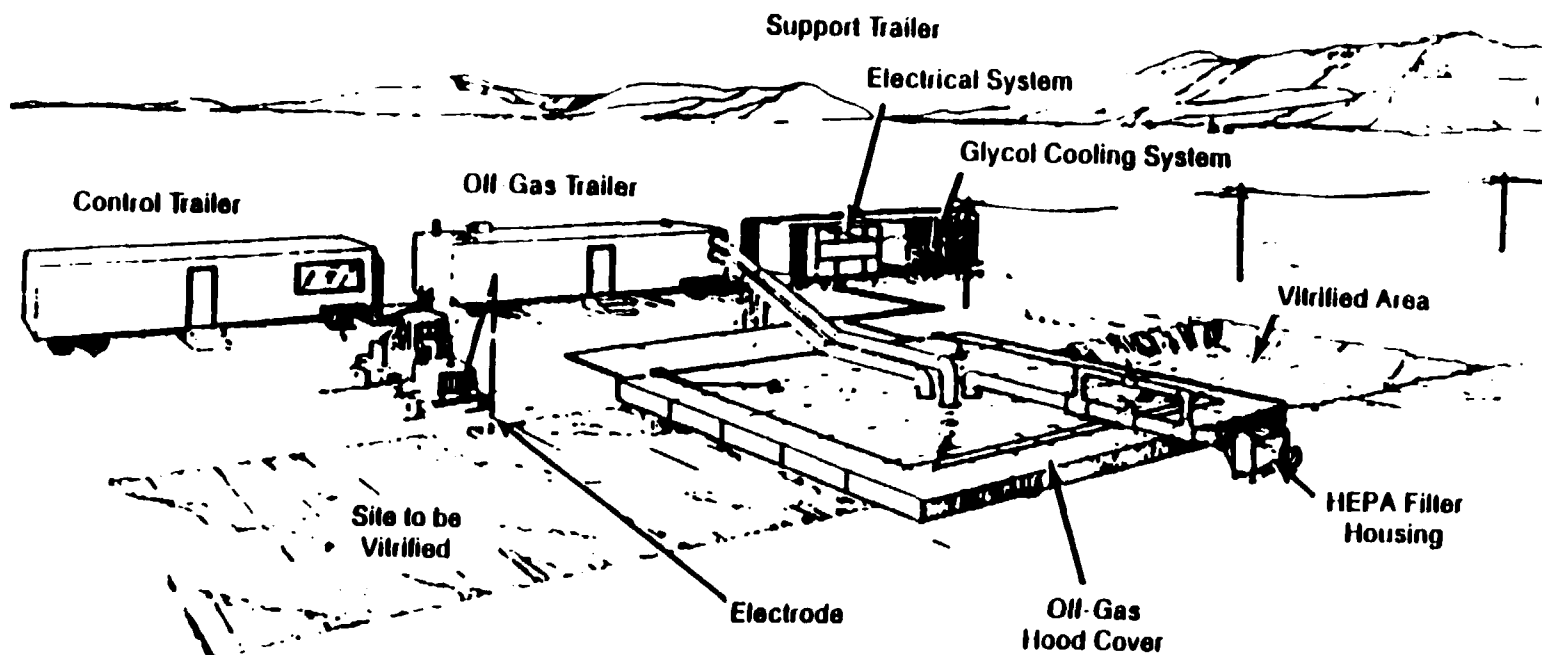
The investigatory/pilot program is not included in the above. Information for this alternative has been developed in part through literature provided by vendors of Pyrogenic, Inc. and Geosafe Corporation. As indicated in Figure 5-1, the components of a large-scale vitrification system include the electrodes, the off-gas containment/collection hood, support and control facilities, and an off-gas treatment facility. Relatively close proximity of support facilities to the area to be treated may be required, and this would complicate application over a large geographic area.

#### **5.5.2 NON COST CRITERIA**

##### **5.5.2.1 TECHNICAL CONSIDERATIONS**

Literature reports indicate that vitrification of contaminated soils results in the formation of a stable glass like and crystalline mass which is quite resistant to leaching and weathering (Oma, et al, 1983). It should therefore, in such applications, result in an essentially permanent remedial technology, as long as no future use of the property would require excavation.

# IN-SITU VITRIFICATION HANDOUT



SOURCE: Standard Handbook of Hazardous Waste Treatment and Disposal.



SPILL PREVENTION & EMERGENCY RESPONSE DIVISION

In Association with ICI Technology Inc., C.C. Johnson & Associates, Inc., Resource Applications, Inc., Geo/Resource Consultants, Inc., and Environmental Toxicology International, Inc.

EPA PM  
Eugene Dominach

TAI PM  
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FIGURE 5-1

NL Industries  
Pedricktown, NJ

Testing has demonstrated that the ISV process is effective at depths up to 10 to 12 feet which is adequate for the wastes at NL site. A major uncertainty in the application of ISV process to material such as exists at the NL site involves the heterogeneity of the materials and the capability of the technology to deal with void spaces and discontinuities. Cement and concrete inclusions are reported to dissolve in the melt. Vitrification of waste material containing containers (e.g., drums) may result release of gas (if any) to be captured in the ISV off-gas hood Oma et al, 1983; Fitzpatrick, 1987a).

The existence of the shallow water table in the base of the vitrified area may affect ISV operations. Energy requirements and cost will increase due to the necessity for evaporating this moisture. If an electrical short circuit is achieved the process will be compromised.

Operational cautions which should be considered in the implementation of ISV may include potential for accidental gas release due to hood failure, and precautions associated with high temperature and high voltage equipment.

Current information on the processing rate for vitrification indicates that complete vitrification of the NL site, assuming 24 hours/day of operation, may take approximately 1 year.

While research and pilot testing of this process indicates promise for application in heterogeneous materials it has not been demonstrated for highly heterogeneous materials such as are present at the NL site. Substantial development work is likely to be required prior to selection of this option.

#### **5.5.2.2 INSTITUTIONAL CONSIDERATIONS**

The following institutional considerations apply to this alternative:

- o This alternative is likely to achieve or exceed cleanup levels or metals in waste materials, and will substantially reduce contribution of all contaminants to the surface and ground water. The immobilization of metals in the glass matrix will reduce incidental exposure to these contaminants, but any future use as construction which require excavation of the material may result in some hazard.
- o Government and local opposition to this alternative as along term solution would likely be limited to concern over long-term prohibition of future land use, as with certain other options. Long-term impact in terms of maintenance monitoring or surveillance should be relatively low;

- o Short term impact on the surrounding community would be those related to construction activities at the site (noise, traffic). Local concerns which may arise about the potential for uncontrolled accidental release of combustible gas from the hood can be addressed during the public information phase, and
- o Materials likely to be transported off-site under this alternative would be limited to the debris removal to clean out the whole site. Part of the hazardous waste (standing water and building wash water) need to be handled in a selected technology option as part of remediation phase.

#### **5.5.2.3 PUBLIC HEALTH AND ENVIRONMENTAL ISSUES**

The following public health and environmental issues should be considered:

- o This alternative would appear to provide adequate long-term protection of public health and the environment, so long as the solidified mass is left intact and in place, and
- o As long as air emissions from the off-gas hood are effectively and consistently controlled, the degree of short-term (implementation phase) hazard to public health and the environment should not be excessive.

#### **5.5.3 COST CRITERIA**

Cost evaluation for implementation of this alternative is shown in Table 5-6 and 5-7. Cost for the actual vitrification process have been developed from vendor contact and should be considered speculative in the absence of testing and detailed treatability analysis.

### **5.6. ALTERNATIVE 5 - HYDRO-METALLURGICAL LEACHING PROCESS**

#### **5.6.1 DESCRIPTION**

The hydro-metallurgical leaching treatment alternative would involve extraction of heavy metals from the toxic waste materials and recovery of the dissolved metals into a saleable product from the existing toxic residues. The technology process would likely be based upon principles of hydro-metallurgy commonly used for the extraction of metals from the ores. The primary implementation options under this alternative would be (1) on-site treatment mainly involve leaching and filtration tanks (see Figure 5-2) which would be build/constructed and operated on-site for the duration of the cleanup effort, and (2) transportation of treated materials to an off-site commercial RCRA landfill for

TABLE 5-6

ALTERNATIVE 4 - PRELIMINARY ESTIMATE, CAPITAL COST --  
IN-SITU VITRIFICATION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1	Site preparation			
	Excavation of vitrified area for vitrification (save excavated material for reburial)	1,500 c.y.	5/c.y.	\$ 7,500
2	Vitrication process			
	Laboratory evaluation and Process Development	Lump sum		
	- laboratory scale	Lump sum		\$ 50,000
	- pilot scale	Lump sum		\$ 150,000
	Vitrification processing	9,200 c.y.	300/c.y.	\$2,760,000
3	Reburial of overburden	1,500 c.y.	6.00/c.y.	\$ 9,000
4	Makeup fill, plus soil cover, 2 ft. total	1,000 c.y.	20/c.y.	\$ 20,000
5	Grading/Vegetation	2 ac	10,000	\$ 20,000
6	Clearing drums, debris and other waste material	4,000 c.y.	16.00/c.y.	\$ 64,000

(continued)

TABLE 5-6

ALTERNATIVE 4 - PRELIMINARY ESTIMATE, CAPITAL COST --  
IN-SITU VITRIFICATION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
7	Excavation of contaminated soil, slag piles and other waste materials for vitrification	9,200 c.y.	5.00/c/y.	\$ 46,000
8	Off-site disposal of vitrified material (assumes 450 c.y.)	300/tons	1,175/ton	\$ 352,000
9	Engineering/oversight personnel through Implementation Phase (3 persons) (1 year)	1,500	70	\$ 105,000
10	Subtotal			\$3,584,000
11	Mobilization/Demobilization (25%) Construction management, site services			\$ 896,000
12	Technology Implementation, designs, plans, specifications, regulatory approval, insurance bonds, permits (30%)			\$1,075,200
13	Overhead and Profit (10%)			\$ 358,400
13	Contingency (25%)			\$ 896,000
15	TOTAL (rounded)			\$ 6,809,600

TABLE 5-7

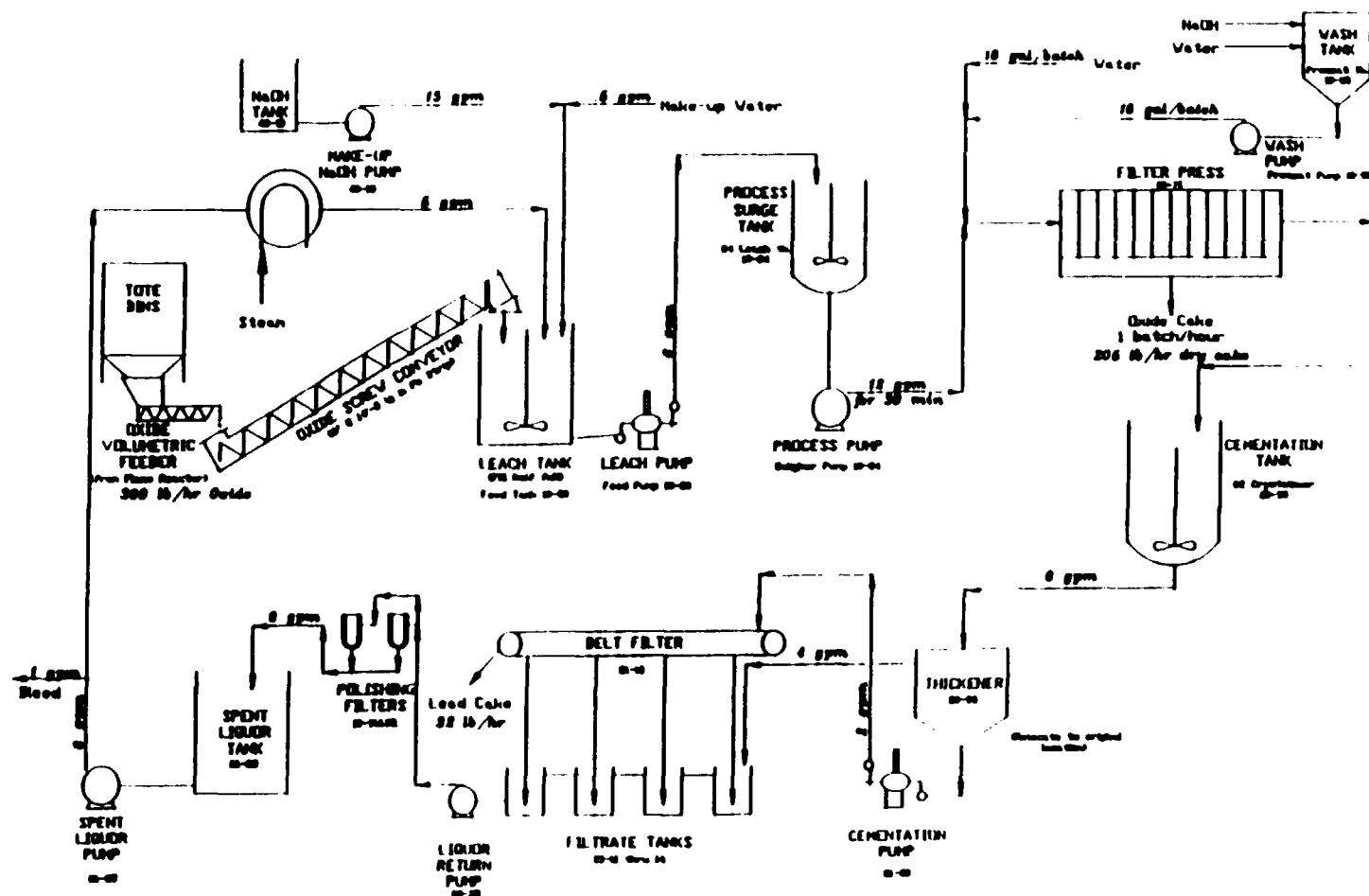
ALTERNATIVE 4 - PRELIMINARY ESTIMATE, OPERATING AND MAINTENANCE COSTS --  
IN-SITU VITRIFICATION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1	Security inspection, quarterly, 8 hr.	32 hr	70/hr	\$ 2,240
2	Surface water monitoring (annually)	8 hr	70/hr	\$ 2,100
	o Analytical: metals plus blank duplicate	6 samples Lump sum	1200/ea 1000	\$ 7,200 \$ 1,000
3	Maintenance			
	o Fence repair	500 ft/yr	6/ft	\$ 3,000
	o Vegetation control	15,000 s.y.	.30 s.y.	\$ 4,500
4	Reporting/Documentation			
	o Annual: engineering report preparation	40 hr.	70/hr	\$ 2,800
5	ANNUAL TOTAL			\$22,840
6	Present worth (rounded)*			\$6,866,400/year for 3 years

\* Assumes 3 year maintenance, post remediation, removal phase takes 1 year.



# HYDROMETALLURGICAL LEACHING PROCESS PILOT PLANT FLOW SHEET



SOURCE: Flame Reactor Process for  
Electric Arc Furnace Dust.

**WESTON**

SPILL PREVENTION &  
EMERGENCY RESPONSE DIVISION

In Association with ICI Technology Inc., C.C. Johnson & Associates,  
Inc., Resource Applications, Inc., Geo/Resource Consultants, Inc.,  
and Environmental Toxicology International, Inc.

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FIGURE 5-2

NL Industries  
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disposal. Included as a baseline in this overall alternative is the suboption of off-site disposal of all treated materials. This permits comparison between the cost of the treatment and the cost of direct redisposal. Other alternatives which involve treatment of waste materials may also be compared to this baseline.

The hydro-metallurgical treatment technology would be expected to exceed source control cleanup criteria for the identified contaminants. However, the process is depending upon the ability of caustic solutions to efficiently extract oxidic lead compounds from the complex residue. To some extent, such solution may not significantly attack the contaminant because of inert material present in the residues. The advantage of this treatment is that lead metal are recovered from the leach solution using a variety of reactive metals such as scrap aluminum chips.

As an alternative, one of the leaching-based innovative technologies separates metals from the waste residue and recovers the metal for a saleable product in the market as a non-hazardous material. However, this alternative seems to be economical and slightly lower in cost than the soil washing and or in-situ soil flushing processes. However, substantial investigation/pilot work would be necessary before selecting this alternative.

All waste materials would be excavated or physically removed under this alternative. The extent of excavation may range from selected areas of contamination to the entire site depending on the remedial goals. The general outline to a hydro-metallurgical leaching process for the NL site would include the following operations:

- o Excavation/removal of waste materials and "hot spots" or contaminated soils;
- o Manual sorting (using construction equipment) of large debris from the waste materials (furnace bricks, facility equipments and other debris) for separate decontamination process (stream jet/laser jet washing). The materials must be provided prior to hydro-metallurgical leaching to prevent damage to the process equipment;
- o Staging of excavated, pre-sorted material for processing;
- o Mechanical shredding of materials to facilitate and protect the process equipment and improve the efficiency of treatment process;
- o Hydro-metallurgical leaching process;
- o Sampling of treated materials for residual contamination as well as leach solution;

- o Provide on or off-site disposal of treated materials, and
- o Clearing of the site, grading and vegetation.

While this evaluation is based primarily upon demonstrated pilot test case studies (L.Lherbier, 1988), the pilot test program is not included in the above. Information for this alternative has been developed in part through literature provided by a single vendor Pittsburgh Mineral and Environmental Technology, Inc. As indicated in Figure 5-4, the components of a pilot plant leaching process include the oxide volumetric feeder, leach tank, process surge tank, filter press, cementation tank, filtrate tanks, polishing filters, and spent liquor tank (see Figure 5-2).

## **5.6.2 NON COST CRITERIA**

### **5.6.2.1 TECHNICAL CONSIDERATIONS**

The ability of hydro-metallurgical leaching process to remove metals identified at the NL site is reasonably certain. The basic metallurgical process was supplemented by the incorporation of an filter press (lead sponge) and spent liquor tank before bleeding solution to lead cake. A trial leaching process would likely be needed to determine the efficiency of this alternative.

A major consideration in determining the feasibility and cost effectiveness of hydro-metallurgical leaching process is the material throughput rate of the system, and the percent (%) of the metallic content being removed. Truly portable systems, which are limited in size, would be sufficient to treat the waste material at NL site. For this reason, a fairly small to medium hydro-metallurgical leaching system needs to be mobilized on-site; at the end of the project the system would be demobilized, disassembled and removed.

Excavation of the fill materials at the NL site will be complicated by the presence of large objects, such as furnace bricks, drums, process equipment and fiber bags which need to be pre-sorted for decontamination purposes. This factor will affect all alternatives which require excavation, and is not unique to the hydro-metallurgical leaching process.

The actual implementation of the various operations required under this alternative is straightforward, as all are conventional technologies.

### **5.6.2.2 INSTITUTIONAL CONSIDERATIONS**

The following institutional considerations apply to this alternative:

- o Treated materials may retain some low concentrations of contaminants;

- o The off-site disposal of treated materials must be the requirements of the cleanup criteria. This treatment should approach the stated goal of reducing toxicity and /or volume of wastes considered for off-site disposal;
- o The potential for relatively high process throughput rates may, depending upon the rates of other components (such as excavation and post treatment sampling) help and minimize impacts arising from effort. These (short-term) impacts would primarily be those associated with the heavy construction work, with respect to noise and traffic;
- o Off-site disposal of pre-sorted debris, treatment process concentrate streams (bleed liquid), and any unsuccessfully decontaminated wastes will require compliance with Federal and State DOT requirements for handling, transport, and tracking of hazardous wastes;
- o Local discharge of final, treated, wash waters will require a NPDES permit or local sewer discharge approval.

#### **5.6.2.3 PUBLIC HEALTH AND INSTITUTIONAL ISSUES**

The following public health and environmental issues should be considered:

- o This alternative should be expected to provide adequate protection of public health from hazards associated with direct contact with site materials. It can be also expected to effectively eliminate the contribution of this site to further surface water contamination and air pollution, however, the performance of the system clean-up goals should be demonstrated prior to implementation, and
- o Depending upon the contaminants and the reagents used, vapor emissions from the process may have to be examined.

#### **5.6.3 COST CRITERIA**

An evaluation of costs associated with this alternative is contained in Tables 5-8 and 5-9.

TABLE 5-8

## ALTERNATIVE 5 - PRELIMINARY ESTIMATE, CAPITAL COST -- HYDRO-METALLURGICAL LEACHING PROCESS

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1	Waste handling			
	o slag piles,	5,000 c.y.	5.00/c.y.	\$ 25,000
	o standing water bottom sediment	200 c.y.	6.00/c.y.	\$ 1,200
2	Presort debris, equipment and drums for future treatment restaging	4,000 c.y.	16.00/c.y.	\$ 64,000
74 3	Hydro-metallurgical leaching process (9,200 cy = 6,210 tons)			
	Laboratory evaluation and process development			
	- Laboratory scale	Lump sum		\$ 20,000
	- Pilot scale	Lump sum		\$175,000
	o mechanical shredding, 15 ton/hr (to avoid equipment damage and increase contact between solvent and contaminants)	Lump sum 6,500 tons	20/ton	\$130,000

(continued)

TABLE 5-8

## ALTERNATIVE 5 - PRELIMINARY ESTIMATE, CAPITAL COST -- HYDRO-METALLURGICAL LEACHING PROCESS

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
	Hydrometallurgical leaching process			
	o includes treatment/recycle of wash solution and disposal, approximately 100 cy/day	6,500 tons	70/ton	\$ 455,000
4	Disposal of treated material			
	o testing of treated material, one sample per 500 cy. Sample and analysis for VOA/BNA/metals (incl. blanks)	20	1,200 ea.	\$ 24,000
5	Water supply for hydrometallurgical leaching process	250 loads	500/load	\$ 125,000
6	Grading/Vegetation	2 ac	10,000	\$ 20,000
7	Engineering/oversight personnel through implementation in phase (4 persons, one year each)	10,000 hr	70/hr	\$ 700,000
8	Subtotal			\$1,739,200
9	Mobilization/Demobilization (25%) Construction management, site services			\$ 434,500

(continued)

TABLE 5-8

## ALTERNATIVE 5 - PRELIMINARY ESTIMATE, CAPITAL COST -- HYDRO-METALLURGICAL LEACHING PROCESS

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
10	Technology Implementation, designs, plans, specifications, regulatory approval, insurance bonds, permits (30%)			\$ 521,760
11	Overhead and Profit (10%)			\$ 173,920
12	Contingency (25%)			\$ 434,800
13	Sub Total			\$3,304,480
14	Assume recovery of lead 35% per ton and market sellable value \$47/ton (Credit)	2,275 tons	\$47/ton	\$ 106,925
15	TOTAL (rounded)			\$3,197,500

TABLE 5-9

ALTERNATIVE 1 - PRELIMINARY ESTIMATE OF OPERATING AND MAINTENANCE COSTS ---  
HYDROMETALLURGICAL LEACHING PROCESS

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1	Security Inspection, quarterly, 8 hrs/quarter	32 hr.	70/hr	\$ 2,240
2	Surface water Monitoring (Annual)	8 HR	70/hr	\$ 2,100
	o Analytical: metals plus blank/duplicate	6 samples	1200/ea	\$ 7,200
	o Expenses: annual	Lump sum	1000	\$ 1,000
3	Maintenance			
	o Fence repair	500 ft/yr	6/ft	\$ 3,000
	o Vegetation Control,	15,000 s.y.	0.30 s.y.	\$ 4,500
4	Reporting/Documentation			
	Annual engineering report preparation, quarterly	40 hr	70/hr	\$ 2,800
8	Annual Total			\$ 22,840
9	Present worth (rounded) *			\$3,254,300/year for 3 years

\*Assumes 30 years maintenance, post remediation; removal phase takes 1 year.



## **5.7 ALTERNATIVE 6 - BLEACHING/HYDROBLASTING PROCESS FOR BUILDING DECONTAMINATION**

### **5.7.1 DESCRIPTION**

In order to thoroughly decontaminate the processing building, an aggressive approach is needed. This approach should be easily implemented and provide a thorough decontamination of the building as well as be safe for workers who are doing the job. It is recommended that conjunctive technology, a combination of the bleaching and hydroblasting processes be used. This process will capture the advantages of both processes (See Figure 5-3).

With this process, the building will be thoroughly decontaminated. The bleaching process works well on metal surfaces, and may be used to remove several contaminants. This process uses appropriate bleach formulation to chemically break down the contaminant, and disengage it from the surface. The hydroblasting method physically dislodges the contaminant from the surface and forces it into a sump or other type of holding pool.

The major disadvantage is the amount of bleach/wastewater sludge that will be produced. Rough estimates indicate approximately 1.8 million gallons of wastewater will result due to this process. This wastewater will have to be treated with an ion-exchange unit before being sent off-site.

### **5.7.2 NON COST CRITERIA**

#### **5.7.2.1 TECHNICAL CONSIDERATIONS**

Alternatives to this process are to use any one of the processes individually. However, each process does present a disadvantage if used by itself.

The bleaching process does not allow for a thorough physical degradation of the contaminated area. If employed alone, this process is difficult to remove from the walls, machinery parts, and other affected areas.

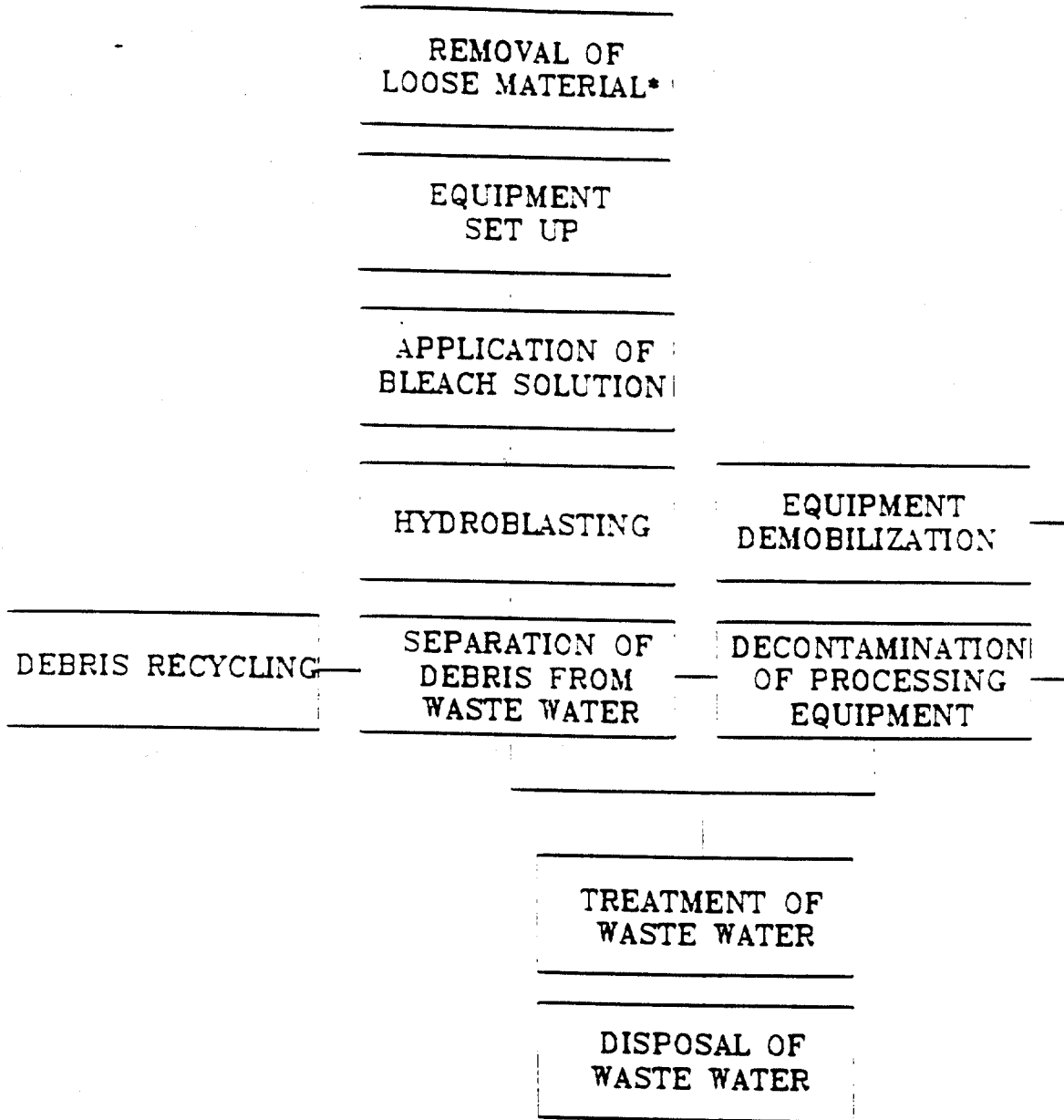
The hydroblasting process is the opposite of the bleaching process does not allow for a thorough chemical degradation of the contaminated area. With hydroblasting, only surface areas will be decontaminated, leaving contamination in the subsurface.

#### **5.7.2.2 INSTITUTIONAL CONSIDERATIONS**

The following institutional considerations apply to this method.

- o The waste stream from the decontamination procedure will contain a large concentration of lead. This stream will have to be at compliance levels before being sent off-site to a treatment plant.

# BLEACHING/HYDROBLASTING PROCESS



## NOTE:

\* DEAD BIRDS & TRASH



SPILL PREVENTION &  
EMERGENCY RESPONSE DIVISION

In Association with ICF Technology Inc., C.C. Johnson & Associates, Inc., Resource Applications, Inc., Geo/Resource Consultants, Inc., and Environmental Toxicology International, Inc.

EPA PM  
Eugene Dominach

TAT PM  
V. Reddy/J. Manfreda

FIGURE 5-3

NL Industries  
Pedricktown, NJ

- o Off-site disposal of presorted debris and other unsuccessfully decontaminated wastes must comply with Federal and State DOT requirements for handling, transport and tracking of hazardous wastes.
- o Local discharges of final, treated, wash waters will require NPDES permits or local sewer discharge permits.
- o During the decontamination process, the possibility of the contaminant being forced to circulate throughout the building is great. This will necessitate constant air monitoring of the building, to ensure workers are not being exposed to levels of lead dust that exceed the permissible levels of the protective equipment.

#### **5.7.2.3 PUBLIC HEALTH AND ENVIRONMENTAL ISSUES**

The following public health and environmental issues should be addressed:

- o Since this alternative will result in removal of contaminants from the NL site, it will prove effective in minimizing future threats to the public health and welfare near the site. However, the performance of the system's clean-up goals should be demonstrated prior to implementation.
- o Depending on the contaminants and the solvents used, air emissions from the process may have to be examined.

#### **5.7.3 COST CRITERIA**

Cost evaluation for the implementation of this process is presented in Table 5-10. It is not known whether this conjunctive technology has been applied at another installation, so the implementation costs may be speculative.

### **5.8 ALTERNATIVE 7 - ION EXCHANGE**

#### **5.8.1 DESCRIPTION**

The DeVoe-Holbein resin removes metals from wastewater, thereby meeting discharge regulatory standards. This process has a removal efficiency of 99.99% in areas where the metals concentrations can range from 0 to 1,000 ppm. This process significantly reduces the volume of waste after treatment. See Section 4.12 for additional details.

TABLE 5-10

ALTERNATIVE 6 - PRELIMINARY ESTIMATE, TOTAL COST --  
BLEACHING/HYDROBLASTING PROCESS FOR BUILDING CONTAMINATION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1.	Equipment			
	o Holding pools (2)	50,000 gal.	641/mo	\$ 2,564
	o Laser jet wash unit (1)	Lump sum	4100/mo	\$ 8,200
	o Vacuum unit (1)	Lump sum	3435/mo	\$ 6,870
	o Pumps w/hoses (2)	Lump sum	400/mo	\$ 1,600
	o Bleaching agent/ calcium hypochlorite	Lump sum		\$ 20,000
	o Response technicians (4)	1920 hr.	25.36/hr.	\$ 48,961
	o Chemist (2)	1000 hr.	54.02/hr.	\$ 54,020
2.	Wastewater Treatment by Ion Exchange	Lump sum*		\$ 280,000
3.	Wastewater Treatment by Chemical Precipitation and Separation	Lump sum**		\$ 545,000
4.	Disposal of Treated Water			
	(Assumes 2.0 million gallons; 1.3 million gallons from hydroblasting and .7 million gallons from bleaching process)	400 loads	500/load	\$ 200,000

TABLE 5-10

ALTERNATIVE 6 - PRELIMINARY ESTIMATE, TOTAL COST --  
BLEACHING/HYDROBLASTING PROCESS FOR BUILDING CONTAMINATION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
5.	Transportation of Treated Water			
	(Assumes 2 million gallons)	400 loads	500/load	\$ 200,000
	TOTAL COST (Excluding Chemical Precipitation and Separation Technology)			\$ 822,215
	TOTAL COST (Excluding Ion Exchange Technology)			\$1,087,215

\*Itemized cost (details see Table 5-11)

\*\*Itemized cost (details see Table 5-12)

## **5.8.2 NON COST CRITERIA**

### **5.8.2.1 TECHNICAL CONSIDERATIONS**

The process will protect human health and the environment. The waste waters will be treated and eliminate the chances of the standing water contaminating soil and groundwater. Treated water must meet the state discharge requirements before being discharged to the sewer. The concentrated metal waste will be sent off-site to be recycled.

Once the waste is treated and the concentrated metal solution is recycled, no further remediation will be necessary for the standing water. Therefore, this technology is permanent and has long term effectiveness. This technology eliminates the toxicity, mobility and volume of the waste stream.

It is believed this treatment method will be accepted by the State and community. Nothing will be left onsite from the treatment process.

### **5.8.2.2 INSTITUTIONAL CONSIDERATIONS**

The ion exchange treatment process creates two products, a treated water (effluent) and a concentrated metal (recovered metals). If treated water meets the NJDEP effluent standards, the effluent can be discharged to a wastewater treatment facility. The recovered metals from the process will be sent to an industry for recycling.

### **5.8.2.3 PUBLIC HEALTH AND ENVIRONMENTAL ISSUES**

By treating the standing water, ion exchange will eliminate the possibility of further groundwater and soil contamination. This technology will therefore be beneficial to the public health and the environment. Treated water will be discharged to the local sewer, but only when it meets NJDEP discharge requirements.

## **5.8.3 COST CRITERIA**

No previous studies have been done to give an accurate cost estimation for using ion exchange on hazardous wastes comparable to the standing water found at the National Lead site. Therefore, an estimated cost of \$905,000 is given for treatment of the wastewaters found at the site (see Table 5-11).

## **5.9 ALTERNATIVE 8 - CHEMICAL PRECIPITATION AND SEPARATION**

### **5.9.1 DESCRIPTION**

Chemical precipitation has been used successfully to treat metal contaminated waste waters in industry and municipally owned wastewater treatment plants. This technology can also lower metal concentrations in the product stream to less than 1 mg/l.

TABLE 5-11

ALTERNATIVE 7 - PRELIMINARY ESTIMATE, TOTAL COST --  
ION EXCHANGE

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1.	Ion Exchange Unit	*3 million gallons treatable capacity		\$ 125,000
2.	Operation and Maintenance	Lump sum for one year		\$100,000
3.	Set up lab on-site for treated water analysis with one chemist	Lump sum		\$ 50,000
4.	Bench/pilot scale test before process implementation	Lump sum		\$ 30,000
5.	Disposal cost for treated water at wastewater treatment plant	400/each	\$500/load	\$200,000
6.	Transportation of treated water to waste water treatment plant.	400/each	\$500/load	\$200,000
	TOTAL COST			\$705,000

\*Assumes: 2 million gallons of wastewater from building decontamination and 1 million gallons of on-site standing water.

## **5.9.2 NON COST CRITERIA**

### **5.9.2.1 TECHNICAL CONSIDERATIONS**

Chemical precipitation as a treatment of hazardous liquids at the NL site will protect the environment and human health. This technology will also be in compliance with ARARs. However, testing is needed to determine the cost to comply with ARARs and if the technology is economical for consideration. This technology is an effective method for treating liquid wastes. Once the waste is treated it need not be treated again. Chemical precipitation will also effectively reduce the toxicity of the metals by oxidation.

Oxidized metals will be in solid form, thereby reducing their mobility and reducing the volume of hazardous liquid. This method will also be accepted by the state and local community. This method is used extensively in industry and in their own public water treatment works.

### **5.9.2.2 INSTITUTIONAL CONSIDERATIONS**

The products of this treatment method are a treated water stream and a metal oxide sludge. The treated water stream can be discharged to the local sewer if it meets NJDEP permit standards. A permit will have to be obtained and will set the standards of metal concentrations in the treated water stream.

The metal oxide sludge can be landfilled. Metal oxides are non-toxic and the mobility of the waste is reduced.

As this treatment method only produces liquid product streams, air solution is not a problem for chemical precipitation.

### **5.9.2.3 PUBLIC HEALTH AND ENVIRONMENTAL ISSUES**

This technology shall protect public health and the environment. This method will prevent further contamination of the soil and groundwater by treating the liquid waste. The treated water will be discharged to the local authority if it meets NJDEP discharge limits.

The metals originally in the waste stream are changed to metal oxides, which are less toxic and can be landfilled. At this point, the liquid hazardous waste needs no further treatment.

## **5.9.3 COST CRITERIA**

The cost estimate for complete treatment of the wastewater is presented in Table 5-12 including disposal of stabilized sludge and treated water.



TABLE 5-12

ALTERNATIVE 8 - PRELIMINARY ESTIMATE, TOTAL COST --  
CHEMICAL PRECIPITATION AND SEPARATION

ITEM	DESCRIPTION	QUANTITY	UNIT COST, \$	TOTAL COST, \$
1.	Equipment and Chemicals	*3 million gallons treatable capacity		\$250,000
2.	Operation and Maintenance	Lump sum for one year		\$120,000
3.	Set up lab on-site for treated water analysis with one chemist	Lump sum		\$ 50,000
4.	Bench/pilot scale test before process implementation	Lump sum		\$ 60,000
5.	Disposal of sludge at approved landfill treatment plant	120 tons 6 truckloads	\$200/ton	\$141,000
6.	Disposal cost for treated water at wastewater treatment plant	400/each	\$500/load	\$200,000
7.	Transportation of treated water to waste water treatment	400/load	\$500/load	\$200,000
	TOTAL COST			\$1,021,000

\*Assumes 2 million gallons of wastewater from building decontamination and 1 million gallons of on-site standing water.

\*\*Includes transportation.

## **6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES**

### **6.1 BASIS OF COMPARISON**

In this section, the selected remedial alternatives are presented in concise tabular form in order to facilitate direct comparison of advantages/disadvantages associated with each. The comparison is presented according to the same general categories as used in the detailed evaluation section:

- o Technical Considerations;
- o Institutional Considerations;
- o Public Health Environmental Issues, and
- o Cost Considerations.

This information is presented in Table 6-1. In addition, a separate, more concise, comparison of present worth costs is presented for various alternatives in Table 6-2.

TABLE 6-1  
EVALUATION SUMMARY OF ALTERNATIVES  
FOR WASTE MATERIALS TO BE TREATED AT NL INDUSTRIES  
PEDRICKTOWN, NEW JERSEY

ALTERNATIVE/WASTE* MATERIAL TO BE TREATED	PRESENT WORTH COST	TECHNICAL CONSIDERATIONS	INSTITUTIONAL CONSIDERATIONS	PUBLIC HEALTH/ ENVIRONMENTAL ISSUES	COMMENT
No Removal Action	\$ 351,300	Technical implementation is straightforward  A continuing site monitoring/security is required.  Interpretation of monitoring data, and evaluation of changes in air quality and surface water conditions.	Under SARA guidelines controls which do not meet applicable requirements be acceptable as an interim measure.  Public opposition may be encountered since no reduction in existing hazards is anticipated.	No significant reduction in excess health risks, except any occurring via natural attenuation, would be expected.  Implementation will not result in significant surface water or air environmental impact.	Does not achieve applicable clean-up criteria.
Minimal Mitigative Action C & E	\$1,725,800	Technical implementation is straightforward continuing monitoring/security program is required.  Interpretation of monitoring data and evaluation of quality in surface water, air and gross contamination on debris is also necessary.	Public opposition may be encountered since no reduction in existing hazards is anticipated;  Local discharge of waste water will require an NPDES permit or local sewer discharge approval.  Require technical and administrative commitment throughout process.	Implementation would result in reduction of some associated health risks.  Implementation would result in significant reduction of gross contamination of debris, and also in contamination of water.	Achieves some cleanup criteria.

\*A = Slag Piles  
B = Lead oxide piles  
C = Other waste areas  
D = Building Decontamination  
E = Standing Water and Building Decontaminated Water

Table A-8 CHEMICAL ANALYSIS OF STANDING WATER  
NL Industries, Pedricktown, New Jersey  
(All Units in ug/liter)

HSL		SMO/TAT SAMPLE NUMBER									AVERAGE
INORGANICS		MBAZ00/	MBAZ01/	MBAZ02/	MBAZ03/	MBAZ04/	MBAZ05/	MBAZ06/	MBAZ07/	MBAZ08/	
CAS No.	PARAMETER	0311-01S	0311-02S	0311-03S	0311-04S	0311-05S	0311-06S	0311-07S	0311-08S	0311-09S	CONC.
7429-90-5	Aluminum	58.7	197	195	266	832	775	619	250	258	383.4
7440-36-0	Antimony	33	200	38.7	84.7	883	2080	33	33	33	379.8
7440-38-2	Arsenic	80	80	80	19.6	22.8	18	80	8	8	44.0
7440-39-3	Barium	37	66	37	42.4	37	37	37	37	37	40.8
7440-41-7	Beryllium	3	3	3	3	3	3	3	3	3	3.0
7440-43-9	Cadmium	419	823	119	320	18.8	28.3	357	11.8	442	282.1
7440-70-2	Calcium	11700	25500	8660	10600	11000	11200	25900	3790	10500	13205.6
7440-47-3	Chromium	8	8	14.1	8	8	8	8	8	8	8.7
7440-48-4	Cobalt	217	56.8	9.8	8	8	8	20.4	8	213	61.0
7440-50-8	Copper	702	146	107	122	25.4	52.7	65.4	21.9	770	223.6
7439-89-6	Iron	503	2420	678	2100	400	1150	1160	89.4	490	998.9
7439-92-1	Lead	3270	3080	2000	4070	705	1180	4390	160	3160	2446.1
7439-95-4	Magnesium	3960	5170	1480	1120	1400	1620	3550	1750	4170	2691.1
7439-96-5	Manganese	328	137	26.3	53.7	31.4	85.2	191	14.7	251	124.3
7439-97-6	Mercury	0.3	0.38	0.2	0.4	0.2	0.2	0.3	0.2	0.2	0.3
7440-02-0	Nickel	343	79.7	26.4	21.8	14	14	46.4	14	337	99.6
7440-09-7	Potassium	4000	4200	10800	5700	3160	4800	3160	3160	3500	4720.0
7782-49-2	Selenium	50	5	5	50	5	5	5	5	5	15.0
7440-22-4	Silver	7.4	7	7	7	7	7	7	7.4	9	7.3
7440-23-5	Sodium	155000	698000	162000	44000	296000	272000	279000	3430	156000	229492
7440-28-0	Thallium	6	6	6	6	6	6	6	6	6	6.0
7440-62-2	Vanadium	12	20.4	12	12	12	12	12	12	12	12.9
7440-66-6	Zinc	7230	1520	311	632	168	105	2900	72	7200	2237.6
	Cyanide										

TABLE 6-1  
EVALUATION SUMMARY OF ALTERNATIVES  
FOR WASTE MATERIALS TO BE TREATED AT NL INDUSTRIES  
PEDRICKTOWN, NEW JERSEY

ALTERNATIVE/WASTE* MATERIAL TO BE TREATED	PRESENT WORTH COST	TECHNICAL CONSIDERATIONS	INSTITUTIONAL CONSIDERATIONS	PUBLIC HEALTH/ ENVIRONMENTAL ISSUES	COMMENT
			Under SARA guidelines controls which do not meet applicable requirements be acceptable as an interim measure.		
			Public opposition may be encountered since no reduction in existing hazards is anticipated.		
8 Hazardous Waste Handling/Waste Material Washing A, B & C	\$4,598,800	Proprietary processes are available which should be applicable for chemical extraction of contaminants from waste material simplifying implementation. Vendors process schemes include treatment of contaminated wash solutions. Processes rely upon known technologies derived from mining and oil recovery businesses.  Pilot testing required.  Substantial pre-sorting and shredding, as well as materials handling/staging complicates clean-up effort.  Length of remedial effort depends on process through put rate selected, may be several years.	Final washwater requires disposal; vendor literature indicates discharge may be technically feasible. Discharge permit may be required.  Off-site disposal of treated materials requires compliance with State and DOT regulations.  Little potential for local opposition during implementation phase.	Should result in permanent reduction in public health threat through direct contact route; public health threat from surface water is unknown.  Relatively little potential for negative public threat or environmental impact during implementation, provided contaminated wash water is managed appropriately.  Periods of open excavation and storage of staged materials on surface requires management of run-off and air emissions of contaminants.	Likely to meet or exceed soil clean-up criteria likely to substantially reduce contamination of surface water from NL site.

TABLE 6-1  
EVALUATION SUMMARY OF ALTERNATIVES  
FOR WASTE MATERIALS TO BE TREATED AT NL INDUSTRIES  
PEDRICKTOWN, NEW JERSEY

ALTERNATIVE/WASTE* MATERIAL TO BE TREATED	PRESENT WORTH COST	TECHNICAL CONSIDERATIONS	INSTITUTIONAL CONSIDERATIONS	PUBLIC HEALTH/ ENVIRONMENTAL ISSUES	COMMENT
In-Situ Treatment (Vitrification) A, B, & C	\$ 6,866,400	<p>Innovative treatment available as a patented process from vendor.</p> <p>Has potential for effective immobilization of metals.</p> <p>Has some potential for treating heterogenous materials and those containing void spaces.</p> <p>Pilot testing required.</p> <p>Implementation phase likely to take several years depending upon size of system.</p>	<p>Likely to meet or exceed clean-up criteria in waste materials.</p> <p>Should result in relatively permanent resolution of existing contamination.</p> <p>While hood is used to collect off gases, any releases must comply with Federal and state air pollution regulations.</p> <p>Off-site disposal of some materials requires compliance with State and DOT regulation.</p> <p>Implementation phase may result in public concern/opposition due to unconventional technology and concern over air release.</p> <p>Implementation would likely preclude any future construction use of property.</p>	<p>Should result in permanent reduction in public health threat through direct contact route (although future construction is precluded in any event), effect of public health threat from surface water or ground water is unknown.</p> <p>Potential for accidental release of gas, resulting in negative impact, is slight.</p> <p>Future use of site is substantially restricted due to inability/difficulty in excavating vitrified mass.</p>	<p>Likely to meet or exceed organic clean-up criteria in waste material; metals level unchanged.</p> <p>Likely to substantially reduce contamination of ground water from NL site.</p>

TABLE 6-1  
EVALUATION SUMMARY OF ALTERNATIVES  
FOR WASTE MATERIALS TO BE TREATED AT NL INDUSTRIES  
PEDRICKTOWN, NEW JERSEY

ALTERNATIVE/WASTE* MATERIAL TO BE TREATED	PRESENT WORTH COST	TECHNICAL CONSIDERATIONS	INSTITUTIONAL CONSIDERATIONS	PUBLIC HEALTH/ ENVIRONMENTAL ISSUES	COMMENT
Hydro-Metallurgical Leaching Process A, B, & C	\$3,254,300	Innovative treatment available as a patented process from vendor.  Pilot testing required.  Substantial pre-sorting and shredding as well as materials handling, staging complicates clean-up efforts.  Length of remedial effort depends on process throughput rate selected may be a year.	Likely to meet or exceed criteria in waste material.  Off-site disposal of treated materials requires compliance with EPA State and DOT regulations.  No local opposition during implementation phase.	Should result in permanent reduction in public health threat through direct contact route effect on public health threat from surface water or air pollution is unknown.  Relatively little potential for negative public threat or environmental impact during implementation, provided treated waste are managed appropriately.  Periods of open excavation and storage of staged materials on surface requires management of run-off and emissions of contaminants.	Exceed clean-up criteria and sub- stantially reduce contamination of surface run-off from the site.
Bleaching/ Hydroblasting D	\$822,200 (excluding chemical precipitation and separation)	Technical implementation is straightforward.  Continuing monitoring/security program required.	Requires technical and administrative commitment throughout the program.  No public opposition should occur.	A significant reduction in health risks would occur.  Implementation may result in increase in environmental impact on surface water.	Achieves applicable clean-up criteria.
	\$1,087,200 (excluding ion exchange)	Interpretation and evaluation of data.			

TABLE 6-1  
EVALUATION SUMMARY OF ALTERNATIVES  
FOR WASTE MATERIALS TO BE TREATED AT NL INDUSTRIES  
PEDRICKTOWN, NEW JERSEY

ALTERNATIVE/WASTE* MATERIAL TO BE TREATED	PRESENT WORTH COST	TECHNICAL CONSIDERATIONS	INSTITUTIONAL CONSIDERATIONS	PUBLIC HEALTH/ ENVIRONMENTAL ISSUES	COMMENT
Ion Exchange D&E	\$705,000	Pilot testing required permit required for treated wastewater.  Has potential for treating wastewater.  Regeneration of the ion exchange resin will require downtime.	NPDES/local sewer discharge permit required for treated water disposal to local sewer.  Concentrated metal solution waste will either be recycled or disposed of off-site.  No local opposition during implementation phase.	Ion exchange will eliminate further contamination of and groundwater from standing water.  Should result in permanent reduction in public health threat from surface water and groundwater.	Sanitech, Inc. will soildonate equipment for standing water treatment.  Likely to meet or exceed metal cleanup criteria in the wastewater.
Precipitation and Separation	\$1,021,000	Pilot testing required  potential for treating wastewater.  A chemical precipitant will have to be selected.  Hexavalent chromium may have to be treated in a pretreatment operation.	NPDES/local sewer discharge permit required for disposal of treated wastewater to local sewer.  Oxidized metal sludge can be landfilled.	Chemical precipitation will eliminate further contamination of soil and groundwater from standing water.  Should result in permanent reduction in public health threat from surface water and groundwater.	Likely to meet orD&E exceed metal cleanup criteria in the wastewater.



04-2

TABLE 6-2

PRESENT WORTH COMPARISON

<u>Alternative</u>	<u>Description</u>	<u>Present Worth</u>
1	No Removal Action with Site Security	\$ 351,300
2	Minimal Mitigative Action - with clearing the site and drainage pathways and maintenance of the site	\$1,725,800
3	Hazardous waste handling/waste material washing	\$4,598,800
4	In-Situ Vitrification	\$6,866,400
5	Hydro-Metallurgical Leaching Process	\$3,254,300
6	Bleaching/Hydroblasting Process	
	Excluding Chemical Precipitation and Separation	\$ 822,200
	Excluding Ion Exchange	\$1,087,200
7	Ion Exchange	\$ 705,000
8	Precipitation And Separation	\$1,021,000

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## **APPENDIX**

Table A-1	Chemical Analysis of Slag Pile A
Table A-2	Chemical Analysis of Slag Pile B
Table A-3	Chemical Analysis of Slag Pile C
Table A-4	Chemical Analysis of Slag Pile D
Table A-5	Chemical Analysis of Lead Oxide Piles
Table A-6	Chemical Analysis of Other Waste Area
Table A-7	Chemical Analysis of Wipe Samples
Table A-8	Chemical Analysis of Standing Water

Table A-1 CHEMICAL ANALYSIS OF SLAG PILE A  
NL Industries, Pedricktown, New Jersey  
(All Units in mg/kg)

HSL INORGANICS		SMO/TAT SAMPLE NUMBER												AVERAGE CONC.
CAS No.	PARAMETER	5146B-01/ 001SP	5146B-02/ 002SP	5146B-03/ 003SP	5146B-04/ 004SP	5146B-05/ 005SP	5146B-06/ 006SP	5146B-07/ 007SP	5146B-08/ 008SP	5146B-09/ 009SP	5146B-10/ 010SP	5146B-11/ 011SP	5146B-12/ 012SP	
7429-90-5	Aluminum	20800	10100	8780	4740	16000	2180	3780	2250	6930	8680	9680	9920	8653.3
7440-36-0	Antimony	377	703	67.7	529	3040	2020	586	644	424	968	553	522	869.5
7440-38-2	Arsenic	633	633	376	427	3580	927	411	116	421	565	1350	886	860.4
7440-39-3	Barium	1560	661	175	778	1010	190	209	12.8	405	871	489	576	578.1
7440-41-7	Beryllium	6.6	3.2	1.5	6.9	6.5	4.8	3.7	5.4	5.3	5.6	6.3	3.7	5.0
7440-43-9	Cadmium	188	229	39.5	80.3	111	53.3	222	131	98.2	359	358	177	170.5
7440-70-2	Calcium	7150	5440	2500	8220	6420	3600	8520	4010	1560	4000	5930	4450	5150.0
7440-47-3	Chromium	640	251	51	124	421	241	244	245	265	354	264	248	279.0
7440-48-4	Cobalt	37.7	26.3	11.1	15.2	74.9	129	268	170	25.7	34.9	37	20.3	70.8
7440-50-8	Copper	1950	1590	430	792	4550	5860	8590	5010	968	1920	3340	909	2992.4
7439-89-6	Iron	125000	72800	32800	167000	130000	131000	88100	143000	133000	127000	144000	81400	114591.7
7439-92-1	Lead	37800	56800	13500	47200	107000	108000	193000	23800	70900	52900	102000	36400	70941.7
7439-95-4	Magnesium	13500	1930	1150	2630	3560	612	2710	848	2020	1540	1720	1870	2840.8
7439-96-5	Manganese	925	588	152	744	855	149	180	242	1000	883	1610	588	659.7
7439-97-6	Mercury	0.094	0.082	0.072	0.069	0.065	0.068	0.087	0.075	0.71	0.092	0.093	0.083	0.1
7440-02-0	Nickel	317	202	84.8	327	1070	424	676	352	190	319	436	217	384.6
7440-09-7	Potassium	68400	25800	2650	8530	29500	53250	56000	47100	5370	20700	20600	39600	31458.3
7782-49-2	Selenium	2.4	1.4	0.92	1	1.4	0.98	1	1	0.83	0.98	0.99	0.97	1.2
7440-22-4	Silver	2.1	2.5	2.1	3.1	5.2	3.4	8.3	7	2	2.5	2.4	2.1	3.6
7440-23-5	Sodium	67500	28200	2370	11000	30800	55500	59100	48600	3860	22000	23100	40800	32735.8
7440-28-0	Thallium	3.7	0.94	0.92	1.4	2.9	0.98	1.5	2.1	0.83	1.6	1.7	1	1.6
7440-62-2	Vanadium	418	305	96.4	174	445	591	386	485	189	521	653	323	382.2
7440-66-6	Zinc	3210	3690	567	1430	4760	3050	6830	2330	1340	4480	4690	1720	3174.8
	Cyanide													

Table A-2 CHEMICAL ANALYSIS OF SLAG PILE B  
NL Industries, Pedricktown, New Jersey  
(All Units in mg/kg)

HSL		SMO/TAT SAMPLE NUMBER							
INORGANICS									
		5146B-13/	5146B-14/	5146B-15/	5146B-16/	5146B-17/	5146B-18/	5146B-19/	AVERAGE
CAS No.	PARAMETER	013SP	014SP	015SP	016SP	017SP	018SP	019SP	CONC.
7429-90-5	Aluminum	1010	3700	5100	3910	3700	4450	2580	3492.9
7440-36-0	Antimony	123	2360	10000	5320	19000	17200	4350	8336.1
7440-38-2	Arsenic	225	842	818	615	224	501	728	564.7
7440-39-3	Barium	13	278	292	87.8	239	474	258	234.5
7440-41-7	Beryllium	7.2	2.5	3	3.3	3.1	3.6	5.6	4.0
7440-43-9	Cadmium	22.4	262	271	137	53.1	258	57	151.5
7440-70-2	Calcium	8950	5420	4760	14100	8150	2510	6720	7230.0
7440-47-3	Chromium	1150	511	224	165	198	181	239	381.1
7440-48-4	Cobalt	33.5	202	181	153	75.6	300	114	151.3
7440-50-8	Copper	1350	3230	4080	7110	4410	4240	3180	3942.9
7439-89-6	Iron	186000	68000	70700	81900	78200	96900	145000	103814.3
7439-92-1	Lead	49600	252010	198000	128000	96400	128000	88800	134401.4
7439-95-4	Magnesium	319	1530	2030	3860	2240	1380	951	1758.6
7439-96-5	Manganese	64.3	469	411	358	173	920	227	374.6
7439-97-6	Mercury	0.079	0.069	0.23	0.081	0.077	0.23	0.76	0.2
7440-02-0	Nickel	137	564	635	539	231	322	352	397.1
7440-09-7	Potassium	61800	32300	25700	22800	47000	5360	33400	32622.9
7782-49-2	Selenium	1.1	0.98	1	0.91	1.1	0.63	0.92	0.9
7440-22-4	Silver	12	3	6.72	6	8.5	3.2	8.3	6.8
7440-23-5	Sodium	63100	35500	27700	25500	50500	5140	36800	34891.4
7440-28-0	Thallium	1.1	1	1	0.9	1.1	1	0.9	1.0
7440-62-2	Vanadium	360	295	296	338	331	300	460	340.0
7440-66-6	Zinc	1700	6980	6050	8420	3960	4350	4080	5077.1
	Cyanide								

Table A-3 CHEMICAL ANALYSIS OF SLAG PILE C  
NL Industries, Pedricktown, New Jersey  
(All Units in mg/kg)

HSL		SMO/TAT SAMPLE NUMBER						
INORGANICS								
		5146B-20/	5146B-21/	5146B-22/	5146B-23/	5146B-24/	5146B-25/	AVERAGE
CAS No.	PARAMETER	020SP	021SP	022SP	023SP	024SP	025SP	CONC.
7429-90-5	Aluminum	5620	6500	8200	7640	5000	6110	6511.7
7440-36-0	Antimony	612	816	500	1540	2730	3150	1558.0
7440-38-2	Arsenic	991	1050	877	1190	1380	1200	1114.7
7440-39-3	Barium	1350	742	1650	2070	2590	2270	1778.7
7440-41-7	Beryllium	7.1	4.4	8.2	10	4.8	8	7.1
7440-43-9	Cadmium	383	162	1460	227	251	211	449.0
7440-70-2	Calcium	8950	6560	6980	6020	6070	8140	7120.0
7440-47-3	Chromium	876	342	354	1440	541	805	726.3
7440-48-4	Cobalt	30.1	35.3	96.4	41.8	29.1	32.5	44.2
7440-50-8	Copper	1410	1710	4060	1790	2600	2030	2266.7
7439-89-6	Iron	182000	235000	203000	264000	129000	208000	203500.0
7439-92-1	Lead	226000	85700	89100	149000	160000	159000	144800.0
7439-95-4	Magnesium	2540	791	1850	2360	1740	2590	1978.5
7439-96-5	Manganese	1360	935	1600	2030	979	1240	1357.3
7439-97-6	Mercury	0.08	0.21	0.089	0.094	0.26	0.19	0.2
7440-02-0	Nickel	858	656	942	1190	538	646	805.0
7440-09-7	Potassium	30300	31400	46300	17800	41000	17500	30716.7
7782-49-2	Selenium	1.2	1.1	1.2	1.3	1.1	1.3	1.2
7440-22-4	Silver	11	10	8.2	8.2	6.9	7.3	8.6
7440-23-5	Sodium	32000	39200	48700	19700	43300	20400	33883.3
7440-28-0	Thallium	2.7	1.1	1.3	1.3	1.1	1.3	1.5
7440-62-2	Vanadium	900	1270	1300	1630	701	569	1061.7
7440-66-6	Zinc	1390	1620	4850	1270	4130	5680	3156.7
	Cyanide							

Table A-4 CHEMICAL ANALYSIS OF SLAG PILE D

NL Industries, Pedricktown, New Jersey

(All Units in mg/kg)

HSL		SMO/TAT SAMPLE NUMBER						
INORGANICS								
		5146B-26/	5146B-27/	5146B-28/	5146B-29/	5146B-30/	5146B-31/	AVERAGE
CAS No.	PARAMETER	026SP	027SP	028SP	029SP	030SP	031SP	CONC.
7429-90-5	Aluminum	7370	6060	2760	9880	4950	2370	5565.0
7440-36-0	Antimony	2100	547	689	47.4	87.2	626	682.8
7440-38-2	Arsenic	2790	2900	2910	334	178	1940	1842.0
7440-39-3	Barium	2780	2520	2930	301	367	1120	1669.7
7440-41-7	Beryllium	9.3	5.8	2.9	2.5	1.2	1.3	3.8
7440-43-9	Cadmium	549	394	308	64.5	58.5	42.4	236.1
7440-70-2	Calcium	6170	14100	11200	6030	4270	12200	8995.0
7440-47-3	Chromium	1280	873	840	218	254	7240	1784.2
7440-48-4	Cobalt	72.6	103	26.6	14.1	8.1	15.2	39.9
7440-50-8	Copper	2730	1850	3090	454	408	716	1541.3
7439-89-6	Iron	254000	163000	10000	47900	36500	38900	92050.0
7439-92-1	Lead	63500	65200	50000	17400	8950	151000	59341.7
7439-95-4	Magnesium	2130	1390	1060	2580	834	10100	3015.7
7439-96-5	Manganese	1640	1400	818	237	332	472	816.5
7439-97-6	Mercury	0.095	0.11	0.16	0.094	0.078	0.072	0.1
7440-02-0	Nickel	1840	2620	445	145	112	490	942.0
7440-09-7	Potassium	19100	34200	35700	6530	11400	63700	28438.3
7782-49-2	Selenium	1.2	1.2	1.5	0.88	0.81	0.95	1.1
7440-22-4	Silver	7.4	12	5.1	3.1	2.4	15	7.5
7440-23-5	Sodium	52000	35200	38700	5930	12400	63900	34688.3
7440-28-0	Thallium	1.2	1.2	1.5	0.88	0.81	0.95	1.1
7440-62-2	Vanadium	554	385	235	120	117	197	268.0
7440-66-6	Zinc	7430	4670	4780	782	993	696	3225.2
	Cyanide							

Table A-5 CHEMICAL ANALYSIS OF LEAD OXIDE PILE  
 NL Industries, Pedricktown, New Jersey  
 (All Units in mg/kg)

BSL INORGANICS		SMO/TAT SAMPLE NUMBER			AVERAGE CONC.
CAS No.	PARAMETER	5146B-32/ 032SP	5146B-33/ 033SP	5146B-34/ 034SP	
7429-90-5	Aluminum	1210	575	874	886
7440-36-0	Antimony	1490	2790	1920	2067
7440-38-2	Arsenic	293	525	614	477
7440-39-3	Barium	220	153	10	128
7440-41-7	Beryllium	0.55	0.64	0.65	1
7440-43-9	Cadmium	650	205	388	414
7440-70-2	Calcium	3150	1550	2350	2350
7440-47-3	Chromium	146	151	140	146
7440-48-4	Cobalt	5.7	4.3	9.8	7
7440-50-8	Copper	132	462	674	423
7439-89-6	Iron	14900	10500	28300	17900
7439-92-1	Lead	437000	361000	101000	299667
7439-95-4	Magnesium	1020	253	429	567
7439-96-5	Manganese	188	60.1	210	153
7439-97-6	Mercury	1.6	1	1.5	1
7440-02-0	Nickel	138	191	342	224
7440-09-7	Potassium	11200	36000	44800	30667
7782-49-2	Selenium	0.73	0.86	0.84	1
7440-22-4	Silver	2.7	8.3	8.9	7
7440-23-5	Sodium	12800	37300	48600	32900
7440-28-0	Thallium	0.8	0.86	0.84	1
7440-62-2	Vanadium	17.3	9.4	14	14
7440-66-6	Zinc	484	946	1430	953
	Cyanide				



Table A-6 CHEMICAL ANALYSIS OF OTHER WASTE AREA SAMPLES  
NL Industries, Pedricktown, New Jersey  
(All Units in mg/kg)

HSL INORGANICS		SMO/TAT SAMPLE NUMBER												
CAS No.	PARAMETER	5146B-57/	5146B-58/	5146B-59/	5146B-60/	5146B-61/	5146B-62/	5146B-63/	5146B-64/	5146B-65/	5146B-66/	5146B-67/	5146B-68/	5146B-69/
		057K	058K	059K	060K	061K	062K	063K	064K	065K	066K	067K	068K	069K
7429-90-5	Aluminum	2120	1890	15.4	126	282	111	479	77.9	3290	64.7	650	2810	174
7440-36-0	Antimony	6140	1.6	78.8	1740	757	76.4	1410	202	35.4	34.2	237	77.2	7.9
7440-38-2	Arsenic	2210	3.1	38.9	455	813	57.4	2270	63.7	4.1	0.8	5.8	51.8	5.6
7440-39-3	Barium	402	12.9	1.1	10	20.8	0.15	335	11000	1460	5910	355	94.5	442
7440-41-7	Beryllium	0.97	9.9	0.011	0.51	0.56	0.051	11.5	0.56	1.9	0.58	0.75	0.9	0.69
7440-43-9	Cadmium	11300	28.4	72.4	204	218	310	82.5	2	16.7	0.97	3.5	10.4	3
7440-70-2	Calcium	1830	4090	13	214	16	50.4	2040	266	1360	278	249	1650	813
7440-47-3	Chromium	58.9	32.6	0.95	21.8	18.4	2.5	1390	4.5	878	2.1	7.5	84.1	8.8
7440-48-4	Cobalt	6	11.7	0.07	3.4	9.96	0.31	33.1	3.7	13.9	3.9	5	6.4	4.6
7440-50-8	Copper	293	16.6	2.1	456	816	25.6	1360	90.8	88.4	7.3	33.4	168	23.8
7439-89-6	Iron	29300	281000	141	9720	2690	1420	335000	6570	51100	749	5700	26100	10700
7439-92-1	Lead	343000	1890	531	605000	552000	556	63100	414000	263000	344000	309000	309000	512000
7439-95-4	Magnesium	604	2090	3.5	170	188	11.4	218	186	443	259	249	3420	700
7439-96-5	Manganese	130	216	0.96	86.4	25	8.3	2160	46.5	369	4.8	17.2	310	45.3
7439-97-6	Mercury	1.9	0.046	0.034	0.19	0.081	3.7	0.7	0.41	0.24	0.063	0.19	0.089	0.068
7440-02-0	Nickel	203	25	1.4	69.5	1990	3.9	3240	240	468	7.7	7.5	34.9	9.2
7440-09-7	Potassium	66000	2490	572	449	2000	1850	2700	1150	180	223	215	1130	118
7782-49-2	Selenium	5	0.49	0.087	5	4.8	0.21	5.5	43.5	4.7	5	6.2	5.3	5.9
7440-22-4	Silver	1.9	2.7	0.12	14	3.6	2	9.1	3.9	2.1	2.9	6.7	8.4	4.6
7440-23-5	Sodium	11900	3220	602	742	1900	1940	2860	1270	225	263	247	7000	722
7440-28-0	Thallium	1.1	0.78	0.033	0.8	0.77	2.7	0.87	0.7	0.76	0.8	0.99	0.85	0.94
7440-62-2	Vanadium	53.1	270	0.61	3.4	7.7	1.6	133	4.3	17.1	3.9	5	30.8	4.6
7440-66-6	Zinc	9130	45.4	85.4	325	163	110	759	60.3	357	42.3	296	69600	55.4
	Cyanide													

(Conti.----)

Table A-6 CHEMICAL ANALYSIS OF OTHER WASTE AREA SAMPLES  
 NL Industries, Pedricktown, New Jersey  
 (All Units in mg/kg)

HSL		SMO/TAT SAMPLE NUMBER											
INORGANICS		5146B-70/	5146B-71/	5146B-72/	5146B-73/	5146B-74/	5146B-75/	5146B-76/	5146B-77/	5146B-78/	5146B-79/	5146B-80/	5146B-81/
CAS No.	PARAMETER	070K	071K	072K	073K	074K	075K	076K	077K	078K	079K	080K	081K
7429-90-5	Aluminum	5850	6730	695	122	1300	1790	502	2050	2580	16000	2110	9500
7440-36-0	Antimony	426	10700	72200	649	115	3730	400	332	5580	1050	6120	856
7440-38-2	Arsenic	135	371	126	3.5	189	1340	659	2180	2980	23.5	1900	1390
7440-39-3	Barium	1160	9.6	1880	374	4280	12	9	201	216	11.1	1030	1890
7440-41-7	Beryllium	0.66	0.82	0.62	0.66	0.61	1.5	0.6	0.8	1.6	1.2	4.3	8.1
7440-43-9	Cadmium	26.1	186	40.1	24.5	56.1	247	244	537	127	44.7	54.8	559
7440-70-2	Calcium	2340	6180	1160	2930	2330	2650	3220	3540	7160	12300	2810	11200
7440-47-3	Chromium	83.9	93	62.2	16.6	71.6	217	17.2	142	129	17.5	676	1200
7440-48-4	Cobalt	11.2	59.4	4.2	4.4	4.1	183	150	12.5	8.7	4.9	63	49.2
7440-50-8	Copper	243	1610	235	204	206	7380	3280	1650	929	13300	2620	1920
7439-89-6	Iron	18000	18700	20800	4620	13200	46200	8880	30200	48500	46900	150000	237000
7439-92-1	Lead	80800	127000	471000	479000	415000	116000	129000	363000	289000	391000	114000	27600
7439-95-4	Magnesium	1300	765	431	3200	1630	731	1530	589	627	1230	1740	1650
7439-96-5	Manganese	138	141	103	25.4	241	154	49.6	175	384	181	1080	1680
7439-97-6	Mercury	0.54	0.26	0.91	0.068	0.17	0.065	0.13	1.6	0.9	0.9	0.11	0.1
7440-02-0	Nickel	29.1	167	13.7	8.8	18.8	418	366	1490	501	3160	767	792
7440-09-7	Potassium	446	400	307	1450	2740	948	3790	365	454	105	1460	1440
7782-49-2	Selenium	5.3	4.8	5.2	5.5	5.3	5.8	4.5	5.5	5.6	5.3	0.66	0.99
7440-22-4	Silver	2.8	3.1	9.4	13.4	6.3	9.4	17.4	2	1.9	16.1	2.9	2.9
7440-23-5	Sodium	746	36200	1930	20100	9410	12100	7670	6350	8300	1260	53900	48000
7440-28-0	Thallium	0.84	0.77	2	0.88	4.8	2.1	3.6	7.4	1.8	4.9	4	1.6
7440-62-2	Vanadium	51.5	92.4	8.7	4.4	10.4	269	14	34.4	28.9	4.1	570	504
7440-66-6	Zinc	471	1670	9940	157	849	4930	10400	10400	2100	6390	4890	3630
	Cyanide												

(Cont i.-----)

Table A-6 CHEMICAL ANALYSIS OF OTHER WASTE AREA SAMPLES  
NL Industries, Pedricktown, New Jersey  
(All Units in mg/kg)

HSL		SMO/TAT SAMPLE NUMBER												
INORGANICS		5146B-82/	5146B-83/	5146B-84/	5146B-85/	5146B-86/	5146B-87/	5146B-88/	5146B-89/	5146B-90/	5146B-91/	5146B-92/	5146B-93/	5146B-94/
CAS No.	PARAMETER	082K	083K	084K	085K	086K	087K	088K	089K	090K	091K	092K	093K	094K
7429-90-5	Aluminum	5210	8380	1110	458	774	11900	8390	324	389	398	1200	1770	2110
7440-36-0	Antimony	769	28.1	2680	7770	38200	594000	6070	13600	14000	2580	4070	629	89.4
7440-38-2	Arsenic	872	1170	7780	595	1690	2.6	1510	4180	3260	4170	6420	1840	30
7440-39-3	Barium	893	21.4	13.9	56.5	760	10	25.4	1050	1260	423	543	144	25.2
7440-41-7	Beryllium	6.7	4.2	5.7	10	0.61	0.67	0.66	0.92	1.9	0.72	2.1	1.5	1
7440-43-9	Cadmium	464	211	225	45.7	473	1.1	89.4	21.6	27.1	74.6	235	287	88.5
7440-70-2	Calcium	9320	10900	3730	170	1290	1270	915	952	1380	1250	2580	20300	146000
7440-47-3	Chromium	562	1020	231	586	126	20000	134	61.9	104	31.2	103	112	88.5
7440-48-4	Cobalt	38.5	26.1	21.4	31	9.1	16.9	42.9	6.6	8.6	43	172	8.2	6.8
7440-50-8	Copper	1060	2870	955	887	1450	16.2	1240	4850	3680	994	2660	1770	28.1
7439-89-6	Iron	192000	138000	172000	218000	10500	12700	13400	36100	60600	27100	67200	50500	15100
7439-92-1	Lead	30100	43400	169000	161000	364000	1500	104000	293000	404000	187000	289000	314000	6250
7439-95-4	Magnesium	2180	2620	893	170	303	13900	265	180	220	298	780	1220	2330
7439-96-5	Manganese	1380	1150	1230	1750	88.7	150	87.2	125	200	93.1	263	281	94.6
7439-97-6	Mercury	0.077	0.1	0.071	0.071	1.4	0.067	0.078	0.055	0.054	0.08	0.086	4.7	0.12
7440-02-0	Nickel	480	399	673	445	774	235	626	447	424	160	470	212	18.3
7440-09-7	Potassium	1290	2050	2180	108	180	112	981	106	107	1440	1430	841	162
7782-49-2	Selenium	9.5	0.76	0.52	4.8	5.5	0.52	5.6	5.3	5.4	1	5.9	5.9	0.81
7440-22-4	Silver	2.4	3.3	2.2	3.3	2	95	5.9	7.3	3.7	2.4	2.9	48.4	3.4
7440-23-5	Sodium	63000	55700	42600	319	4750	3700	17100	443	458	61.9	11300	10100	2210
7440-28-0	Thallium	0.94	1.2	0.83	0.73	0.86	0.83	0.9	0.89	0.86	0.96	0.94	0.94	1.3
7440-62-2	Vanadium	221	785	55.8	64.5	127	124	37.4	7	9.7	47	122	380	8.5
7440-66-6	Zinc	2490	3860	1120	341	6630	52.8	1190	1240	1060	1110	9700	2740	586
	Cyanide													

(Cont i. ----)

Table A-6 CHEMICAL ANALYSIS OF OTHER WASTE AREA SAMPLES  
NL Industries, Pedricktown, New Jersey  
(All Units in mg/kg)

HSL INORGANICS		SMO/TAT SAMPLE NUMBER										
		5146B-95/	5146B-96/	5146B-97/	5146B-98/	5146B-99/	5146B-100/	5146B-101/	5146B-102/	5146B-103/	5146B-104/	5146B-105/
CAS No.	PARAMETER	095K	096K	097K	098K	099K	100K	101K	102K	103K	104K	105K
7429-90-5	Aluminum	855	1120	1730	1580	739	75.3	49.1	380	871	9130	1500
7440-36-0	Antimony	1870	1140	7640	5920	95.1	53.7	9	1.3	5030	3380	226
7440-38-2	Arsenic	1140	703	1710	4060	6.2	10	1.6	4.4	38000	770	108
7440-39-3	Barium	440	33.5	140	11.2	37.3	31.1	10	11	153	285	61.7
7440-41-7	Beryllium	0.67	0.91	10	3.6	13.8	0.84	0.61	14.9	2.4	6.4	9.5
7440-43-9	Cadmium	317	522	337	596	67.2	20.5	4.6	44.4	1920	692	147
7440-70-2	Calcium	2710	2310	774	622	1220	280	200	1220	2050	3850	4350
7440-47-3	Chromium	45.5	128	280	329	2180	427	7.9	2040	246	445	203
7440-48-4	Cobalt	14	34	11.2	9.1	47.4	5.6	40	60.2	39.4	71.8	30
7440-50-8	Copper	542	892	33.9	472	962	33.1	5.9	1070	856	1540	14900
7439-89-6	Iron	21300	36800	256000	107000	342000	12600	1340	349000	69700	169000	255000
7439-92-1	Lead	264000	122000	83100	154000	3830	4020	1220	2560	186000	124000	16900
7439-95-4	Magnesium	602	824	254	362	719	280	200	551	581	3130	766
7439-96-5	Manganese	113	199	1150	331	3050	82.6	11.1	3290	344	834	1840
7439-97-6	Mercury	0.66	0.54	13.7	64	0.13	0.098	0.065	0.071	1.2	1.3	0.07
7440-02-0	Nickel	384	202	114	132	3010	29.8	123	3780	279	374	233
7440-09-7	Potassium	526	556	317	319	1480	339	101	231	523	548	955
7782-49-2	Selenium	0.56	0.43	0.48	0.51	0.51	0.69	0.51	0.53	5.4	9.9	4.5
7440-22-4	Silver	2.2	3	2	2	3.8	2.8	2	2	3.4	3.7	3.5
7440-23-5	Sodium	14400	43400	662	1110	13200	69400	548	8840	14400	1760	3320
7440-28-0	Thallium	0.89	0.68	0.77	3.2	0.82	1.1	0.81	0.85	0.86	1.6	0.72
7440-62-2	Vanadium	37.7	70.1	455	170	72.4	7	452	94.9	82	147	39.7
7440-66-6	Zinc	1100	70.8	459	1090	779	120	25	138	2460	5460	1100
	Cyanide											

(Cont i.-----)

Table A-6 CHEMICAL ANALYSIS OF OTHER WASTE AREA SAMPLES  
 NL Industries, Pedricktown, New Jersey  
 (All Units in mg/kg)

HSL		SMO/TAT SAMPLE NUMBER				AVERAGE
INORGANICS		5146B-106/	5146B-107/	5146B-108/	5146B-109/	
CAS No.	PARAMETER	106K	107K	108K	109K	CONC.
7429-90-5	Aluminum	2290	526	69.4	2850	2405.6
7440-36-0	Antimony	2950	8490	15.1	25200	16216.24
7440-38-2	Arsenic	272	467	157	2790	1905.566
7440-39-3	Barium	298	11	16	40	715.4783
7440-41-7	Beryllium	5.7	0.56	0.84	2.3	3.020037
7440-43-9	Cadmium	127	153	9.3	440	415.8145
7440-70-2	Calcium	967	294	280	2792	5559.724
7440-47-3	Chromium	631	42.4	68.3	99.1	671.0933
7440-48-4	Cobalt	30.2	3.8	5.6	12	28.34037
7440-50-8	Copper	833	170	13.5	1780	1575.881
7439-89-6	Iron	183000	9670	14300	74300	81460.37
7439-92-1	Lead	78700	227000	4230	292000	200929.9
7439-95-4	Magnesium	747	155	280	297	1114.564
7439-96-5	Manganese	1420	71.9	62.4	460	526.8501
7439-97-6	Mercury	2.2	6.7	0.11	0.31	2.105226
7440-02-0	Nickel	1090	143	8.4	2830	606.1698
7440-09-7	Potassium	140	112	795	2540	2140.584
7782-49-2	Selenium	2.1	0.56	29.3	5.2	4.883528
7440-22-4	Silver	3.1	3.9	2.8	1.9	7.055094
7440-23-5	Sodium	559	788	52100	15100	13022.37
7440-28-0	Thallium	0.92	0.89	1.3	0.83	1.418924
7440-62-2	Vanadium	60.2	12.6	7	12.8	110.1171
7440-66-6	Zinc	1240	567	52.8	14200	3732.777
	Cyanide					

Table A-7 CHEMICAL ANALYSIS OF WIPE SAMPLES  
NL Industries, Pedricktown, New Jersey  
(All Units in mg/kg)

HSL		SMO/TAT SAMPLE NUMBER									
INORGANICS		5146B-35/	5146B-36/	5146B-37/	5146B-38/	5146B-39/	5146B-40/	5146B-41/	5146B-42/	5146B-43/	5146B-44/
CAS No.	PARAMETER	035W	036W	037W	038W	039W	040W	041W	042W	043W	044W
7429-90-5	Aluminum	0.024	3.9	0.62	0.35	0.28	0.63	0.081	3.4	0.69	0.96
7440-36-0	Antimony	0.0084	4.5	0.7	0.52	0.36	0.67	0.13	13.3	0.63	0.37
7440-38-2	Arsenic	0.00097	0.58	0.094	0.11	0.081	0.19	0.01	1.2	0.05	0.04
7440-39-3	Barium	0.14	0.72	0.92	0.8	0.6	1.4	0.02	0.017	0.45	0.66
7440-41-7	Beryllium	0.00073	0.015	0.00079	0.00077	0.00075	0.001	0.0011	0.0014	0.00094	0.00095
7440-43-9	Cadmium	0.0012	0.38	0.016	0.014	0.01	0.004	0.01	0.36	0.0081	0.016
7440-70-2	Calcium	0.24	13.6	1.3	0.75	0.7	0.65	0.47	8.7	1.3	0.82
7440-47-3	Chromium	0.0024	2.1	0.025	0.049	0.0038	0.058	0.0036	0.2	0.34	0.035
7440-48-4	Cobalt	0.0049	0.066	0.01	0.0051	0.005	0.0067	0.0072	0.034	0.0062	0.0064
7440-50-8	Copper	0.023	0.69	0.028	0.02	0.015	0.0091	0.0087	0.61	0.017	0.04
7439-89-6	Iron	0.46	445	7.8	4.3	4.5	3.8	1.2	51.5	15.2	5.1
7439-92-1	Lead	0.88	328	48.5	20.6	12.8	97.8	6.5	552	19.9	15.7
7439-95-4	Magnesium	0.24	4.1	0.41	0.28	0.25	0.34	0.36	3.2	3.2	0.32
7439-96-5	Manganese	0.0039	2.8	0.03	0.014	0.017	0.012	0.0098	0.27	0.27	0.018
7439-97-6	Mercury	0.00041	0.00031	0.00031	0.00031	0.0024	0.00035	0.00039	0.0012	0.0004	0.00025
7440-02-0	Nickel	0.0087	0.76	0.017	0.014	0.01	0.013	0.014	0.21	0.21	0.014
7440-09-7	Potassium	0.073	5.6	2.1	1.3	1.1	1.2	0.091	11.1	1	1.2
7782-49-2	Selenium	0.00097	0.0012	0.001	0.001	0.0036	0.0013	0.0014	0.0014	0.0012	0.00079
7440-22-4	Silver	0.0024	0.013	0.0026	0.0026	0.0025	0.0034	0.0036	0.011	0.011	0.0032
7440-23-5	Sodium	0.3	26.5	15.4	7.9	5.4	5.7	2.1	25.8	5.5	6.3
7440-28-0	Thallium	0.00097	0.0025	0.001	0.001	0.001	0.0013	0.0014	0.0014	0.0012	0.0013
7440-62-2	Vanadium	0.0049	0.13	0.035	0.013	0.0058	0.0067	0.0072	0.24	0.24	0.019
7440-66-6	Zinc	0.036	4.5	0.66	0.4	0.35	0.37	119	4	4	0.53
	Cyanide										

(Cont i.-----)

Table A-7 CHEMICAL ANALYSIS OF WIPE SAMPLES  
NL Industries, Pedricktown, New Jersey  
(All Units in mg/kg)

HSL INORGANICS		SMO/TAT SAMPLE NUMBER												AVERAGE CONC.
CAS No.	PARAMETER	5146B-45/ 045W	5146B-46/ 046W	5146B-47/ 047W	5146B-48/ 048W	5146B-49/ 049W	5146B-50/ 050W	5146B-51/ 051W	5146B-52/ 052W	5146B-53/ 053W	5146B-54/ 054W	5146B-55/ 055W	5146B-56/ 056W	
7429-90-5	Aluminum	0.97	0.52	6.3	0.38	0.35	10.2	0.49	0.61	0.76	1.3	0.81	32.7	3.014772
7440-36-0	Antimony	5.2	1.1	1.3	0.26	0.19	3.1	0.16	4.5	6.8	9	4.4	56.2	5.154472
7440-38-2	Arsenic	0.52	0.13	1.3	0.05	0.01	0.87	0.01	1.1	1.4	1.8	1	17.4	1.270271
7440-39-3	Barium	0.017	0.78	0.014	0.67	0.87	0.017	0.84	0.7	0.41	0.64	0.55	0.017	0.511454
7440-41-7	Beryllium	0.001	0.0012	0.036	0.0071	0.0012	0.027	0.0012	0.0011	0.001	0.0011	0.001	0.0064	0.004942
7440-43-9	Cadmium	0.032	0.027	0.54	0.025	0.0034	0.56	0.0021	0.14	0.18	0.22	0.11	3.7	0.289036
7440-70-2	Calcium	2.2	2.2	25.3	1.4	0.063	22.1	0.66	17.5	1.4	16.8	4.6	91.2	9.725136
7440-47-3	Chromium	0.097	0.022	0.78	4.6	0.028	1.2	0.24	0.037	0.31	0.033	0.019	0.38	0.480127
7440-48-4	Cobalt	0.0088	0.0082	0.12	0.014	0.0076	0.11	0.0082	0.0076	0.0063	0.027	0.0065	0.13	0.027531
7440-50-8	Copper	0.1	0.063	1.5	0.1	0.0157	1.7	0.0099	0.67	0.92	1.4	0.39	17	1.150622
7439-89-6	Iron	27.7	3.8	677	193	2.7	589	3.3	3.4	3.2	9.9	4	154	100.4481
7439-92-1	Lead	205	116	87.7	20.7	20.5	149	11.4	53.7	58.6	97.8	38.3	421	108.29
7439-95-4	Magnesium	0.51	0.81	4.5	1	0.38	3.7	0.41	0.44	0.26	0.55	0.46	9.9	1.619090
7439-96-5	Manganese	0.087	0.027	5.5	1.3	0.0047	5.4	0.018	0.025	0.025	0.065	0.027	1.2	0.778122
7439-97-6	Mercury	0.00039	0.00021	0.001	0.00027	0.00017	0.00094	0.00025	0.00026	0.00045	0.00037	0.0066	0.019	0.001665
7440-02-0	Nickel	0.061	0.021	0.64	0.087	0.023	0.7	0.1	0.18	0.33	0.52	0.19	5.2	0.423759
7440-09-7	Potassium	0.35	1.7	5.3	1.9	1.2	70	1.5	1.6	1.1	2.1	1.3	51.5	7.468818
7782-49-2	Selenium	0.0085	0.001	0.0069	0.00089	0.00096	0.00083	0.01	0.019	0.00097	0.012	0.0085	0.084	0.007609
7440-22-4	Silver	0.0034	0.0041	0.017	0.015	0.0038	0.018	0.0041	0.0053	0.01	0.0093	0.0051	0.37	0.023654
7440-23-5	Sodium	28.7	9.7	33.7	6.2	5.9	77.9	6.8	8.8	6.5	11.3	5.6	52.6	16.11818
7440-28-0	Thallium	0.0014	0.0016	0.0011	0.0014	0.0015	0.003	0.0016	0.0015	0.0013	0.0015	0.0014	0.0017	0.001457
7440-62-2	Vanadium	0.1	0.0091	0.29	0.023	0.0076	0.35	0.0082	0.0076	0.0069	0.012	0.0082	0.24	0.080190
7440-66-6	Zinc	0.23	0.53	7.7	5.1	0.42	4.9	0.45	25.7	204	1.3	0.76	42.8	19.44254
	Cyanide													